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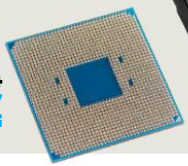

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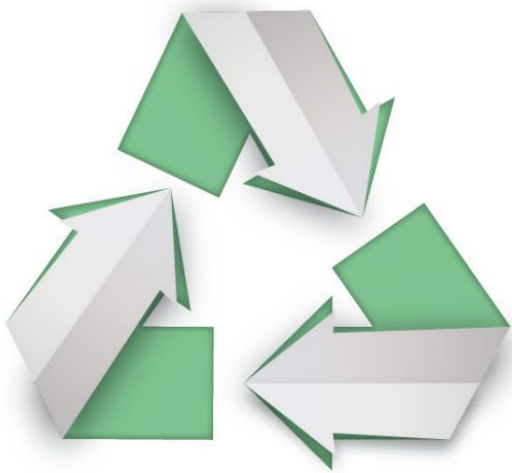

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Zak Storey

YEP...

LOOK, OK, we had two choices when writing the headline for the cover this issue. Either I went with Cool Runnings, or Silence of the Fans. Now, I know, I know, this is a family-friendly magazine, but given that it goes on sale on October 12th, well, I had no choice! What would you do? We rarely get these opportunities, so myself and the team decided to have a little bit of fun with the cover and of course, my Editor's Intro here as well. It's just a one-off. You won't see it again next issue, so don't worry (what I will say, though, is that if an opportunity comes up in the future to use Cool Runnings, and I get to dress up like the legendary John Candy, well... my hands will be tied, just warning you).

Nevertheless, it encapsulates exactly what our feature build is all about this issue. The ultimate, completely fanless PC, from top-to-bottom. Not a single fan has made it into our system this month. Christian reached out to Noctua and managed to hook himself a review sample of the incredibly well-designed NH-P1. This is the first passive CPU heatsink to come out of the company and is capable of comfortably cooling up to an AMD Ryzen 7 5800X or Intel Core i9-11900K. The thing is, well, huge and incredible—in fact, I've seen this cool an Intel Core i9-9900K in the middle of Computex in Taiwan. It's just an awesome piece of design.

For our second feature this month, I sent Sam out to give us the complete low-down on the world of streaming, from where it all began, to how to get started yourself in perhaps one of the more genuine forms of entertainment out there. It isn't just something for the kids these days, there's a live stream for everything, from cooking to home DIY, gaming, PC building, and more. So if you're wondering what you can do in your downtime, and you're keen to get your face behind a camera and on to the world wide web, we've got you covered.

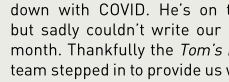
After facing down the likes of Folding@Home, code-breaking in WW2, Y2K, and more, this month, I sent Ian out to find out everything he could about the world of supercomputers. Where did it all begin (spoilers with nukes and the Cold War), how we got to where we are, and where it's going.

He has, of course, sourced some incredible interviews in this one, and for those interested in the world of supercomputing, Cray machines, IBM, and more, it's a phenomenal piece of reporting, and ties in nicely with next issue's full-length feature on Quantum Computing too (also written by Ian).

On top of all that, we've got a full-length guide on getting into Ubuntu, in case you've had enough of Microsoft's Windows blunders, and a ton of tutorials, reviews, builds, and more.

Lastly, our regular news writer, Chris Lloyd, has, unfortunately, come down with COVID. He's on the mend but sadly couldn't write our news this month. Thankfully the *Tom's Hardware* team stepped in to provide us with some much-needed content. Genuinely a lovely group of people, and some of the most knowledgeable folk I know.

Anywho! I hope you enjoy the latest issue of *Maximum PC*, it's been an absolute pleasure to produce and edit, and I'll see you all next month.



Zak is Maximum PC*'s editor-in-chief and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: editor@maximumpc.com

THE NEWS

NSA plans Quantum-Resistant Encryption

Preparing for the challenges of quantum computing

THE U.S. National Security Agency (NSA) has released a document exploring the potential implications for national security following the arrival of a "brave new world" beyond the classical computing sphere.

Entitled "Quantum Computing and Post-Quantum Cryptography FAQs", the document looks at the potential security concerns arising from the creation of a "Cryptographically Relevant Quantum Computer" (CRQC), a quantum-based supercomputer powerful enough to break current encryption schemes.

While these schemes are virtually impossible to crack with current supercomputers, a quantum computer poses a greater threat, due to the superposition states available to its computing unit, the qubit.

It's not just the expected $26 billion value of the quantum computing sphere by 2030 that worries security experts, but the possibility of quantum systems falling into the hands of rogue entities.

The NSA oversees the safety of technological infrastructure in the U.S. and deals with both potential future threats and current ones. As the document says, "a CRQC would be capable of undermining the widely deployed public key algorithms used for asymmetric key exchanges and digital signatures. National Security Systems (NSS)—systems that carry classified or otherwise sensitive military or intelligence information—use public key cryptography to protect the confidentiality, integrity, and authenticity of national security information. Without effective mitigation, the impact of adversarial use of a quantum computer could be devastating to our nation."

The agency's interest in quantum computing isn't new. As part of the document trove leaked by former CIA employee Edward Snowden, it was revealed that the NSA invested $79.7 million in a research program titled "Penetrating Hard Targets", which aimed to explore whether a quantum computer that could break traditional encryption protocols was feasible at the time.

Quantum Computing is set to revolutionize security.

An algorithm that can be employed by a quantum computer to break traditional encryption schemes already exists in the form of Schor's algorithm, which was first demonstrated in 1994. The only thing standing in its way is that it requires a much larger amount of qubits than is presently feasible. Quantum computing will change all that.

The answer lies in the creation and deployment of post-quantum cryptography—encryption schemes designed to thwart future CRQCs. These already exist, but at a time when the cryptographic security threat of quantum computing still lays beyond the horizon, implementing post-quantum cryptography now would present issues in terms of the interoperability of current infrastructure. This would impact how different agencies and branches now share confidential information between themselves.

In the document, NSA says the choice of what type of post-quantum cryptography should be implemented lies with the National Institute of Standards and Technologies (NIST).

But it admits that there's no stopping the march of progress and it's only a matter of time before quantum computing turns the security world on its head. "The intention is to remove quantum-vulnerable algorithms and replace them with a subset of the quantum-resistant algorithms selected by NIST," the NSA says.

Quantum is coming; Post-quantum security must come before it. **–FP**

> "The adversarial use of a quantum computer could be devastating to our nation

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BITCONNECT SCAMMED $2BN FROM INVESTORS

A FAKE TRADING BOT SWINDLED CRYPTO

CYBERSECURITY EXPERTS, the U.S. Securities and Exchange Commission (SEC), claims that BitConnect defrauded retail investors out of $2bn in 2017 and 2018, through a scam involving a crypto trading bot said to offer a guaranteed return on investment. The SEC says that "instead of deploying investor funds for trading with the purported trading bot," BitConnect instead "siphoned investors' funds off for their own benefit by transferring those funds to digital wallet addresses".

That list of affiliates is said to include BitConnect founder Satish Kumbhani, lead promoter Glenn Arcaro, and "a network of promoters around the world." Promoters were allegedly paid commission for their efforts to help the scam find victims.

The SEC also issued an investor alert related to digital assets and crypto, warning that "fraudsters continue to exploit the rising popularity of digital assets to lure retail investors into scams, often leading to devastating losses." **–NM**

NETGEAR SMART SWITCHES POTENTIALLY HACKED

Patched already but highlights flaws in the IoT

CYBERSECURITY EXPERTS found three vulnerabilities in Netgear's smart switches that could be exploited to take control of the devices. Discovered by security researcher Gynvael Coldwind, Netgear has plugged the vulnerabilities and urged users to apply patches immediately.

According to *BleepingComputer*, while most of the affected devices are smart switches, some of them include cloud management capabilities and can be monitored and configured over the internet. Although Netgear's advisory note doesn't include technical details, Coldwind has shared details about the attack vectors of two of the vulnerabilities and listed the scenarios in which affected devices can be exploited to hand over control to attackers.

Coldwind believes Netgear has been conservative in its severity score assessment. Netgear rated it as highly severe with a score of 8.8, but Coldwind believes it deserves 9.8. Exploiting the flaw requires that Netgear's Smart Control Center (SCC) feature is active, which it isn't by default. **–MS**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

U.S. SUPERCOMPUTER
The DoE has invested in an AMD and Nvidia-powered computer with 44 PFLOPs of performance.

INTEL GPUS ARRIVE
Team blue shows off its ARC branding with some impressive tech previews. Its GPUs will arrive in Q1 of 2022.

NOCTUA'S FREE OFFER
Noctua is offering its heatsink customers free upgrade kits for Intel's Alder Lake LGA1700 processors, due to launch soon.

TRAGEDIES

GRAPHICS CARD SUPPLY
Nvidia told shareholders it expects its supply of GPUs to be constrained for most of 2022.

WESTERN DIGITAL SORRY
WD has apologized for changing the SN550's NAND flash from TLC to QLC after launch, and has promised to do better.

PLAYSTATION FIRST
Sony has doubled down on its exclusives going to PlayStation first, despite a recent renewed focus on PC gaming.

APPLE EXPLORING RISC-V CORES

Job Opportunities Open Up for RISC-V Programmers

APPLE IS LOOKING for programmers with knowledge of the RISC-V Instruction Set Architecture (ISA) and ARM's Neon vector ISA for its Vector and Numerics Group (VaNG), which is responsible for developing embedded subsystems on iOS, macOS, watchOS, and tvOS.

Apple's listing doesn't disclose exactly what it plans to do with RISC-V, but the job description indicates that the programmer will have to work with machine learning, computational vision, and natural language processing. Furthermore, the job description also indicates that Apple is already working with RISC-V.

"You will work in an SW and HW cross-functional team which is implementing innovative RISC-V solutions and state-of-the-art routines," the ad reads. "This is to support the necessary computation for such things as machine learning, vision algorithms, signal, and video processing. Push the state of the art in low-level computation and drive them towards energy-efficient and high-performance implementations by tightly integrating software and hardware."

In addition to the SoCs, every Apple device has numerous ARM cores that require Apple to pay a licensing fee to ARM. With the number of cores for things like SSD controllers and smartwatches increasing, so will Apple's payments to ARM. Replacing some ARM cores with RISC-V cores could save Apple millions of dollars in royalty payments every year.

With Apple already working on RISC-V solutions, it is only a matter of time before the company replaces some cores. RISC-V currently focuses on lower-performance applications, but the ISA is developing fast, and the first high-performance RISC-V designs will emerge soon. **–AS**

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GOOGLE DEVELOPING CUSTOM SOC

Google Only Chromebooks Due to Arrive Circa 2023

LIKE OTHER high-tech giants, Google is working on its own custom system-on-chips (SoCs) that will power PCs and tablets running Chrome OS. These SoCs are projected to offer capabilities not available on chips used by today's Chromebooks and are likely to make such machines more competitive.

Google's SoCs for Chromebooks and tablets will be based on ARM architecture, Nikkei reports. It's unclear whether the search giant will develop its own micro-architecture, or use ARM's off-the-shelf Cortex cores. The company intends to roll out its first SoCs for PCs in 2023, but it's not clear which custom features Google intends to add to its SoCs to differentiate them from those developed by companies such as MediaTek or Qualcomm.

Apple was among the first tech firms to build SoCs for smartphones and tablets in 2010. In 2020, it announced plans to stop using Intel CPUs and introduced its M1 SoC to power lightweight laptops. It seems Google now wants to follow suit.

Development of chips is expensive. A complex 5nm design costs over $500 million to develop, but at 3nm, development costs will rise to $1.5 billion, so Google will need to sell a lot of Chromebooks.

Google has been using its own SoCs to accelerate AI workloads in its datacenters since 2016. Last year, it used its Argos video transcoding units (VCUs) to transcode YouTube videos and hired an Intel veteran to develop custom SoCs for its datacenters with the intention of replacing machines based on Intel CPUs. Google confirmed that its Pixel 6 smartphones will be based on its internally designed SoCs. **–AS**

Sony Alters PS5 Cooling

SONY HAS LAUNCHED its latest version of the PlayStation 5 console with a lightweight, more user-friendly design. According to Sony, the new PS5 features a tool-less design for its vertical stand, alongside many other changes.

The reduction in weight has been achieved by redesigning the heatsink and making alterations to the internal PCB, WiFi antennas and more. YouTuber Austin Evans (https://bit.ly/AEYTMPC) got hold of the latest version, the CFI-1102A, and has showcased the internal changes, including a redesigned cooling fan.

From testing, it appears that the older PS5 consoles run cooler than their newer counterpart, meaning that in the long-term, it will perform worse than its launch predecessor. This may be related to Sony's recent announcement that the disk version of its consoles are finally profitable to produce—despite limited availability. A reduction in weight also means the company will save money on freight shipping too, with a total weight saving per unit of 10.58oz.

We assume Sony has done the testing to ensure these consoles stand the test of time, and to know how much of a difference that drop in cooling makes. Companies have made changes to their console lineups before, most notably Nintendo launched a version of the Switch with an updated Nvidia processor back in 2020 that improved battery life and performance. However, usually it's an upgrade not a downgrade. **–ZS**

Corsair's 500mm RGB Fan

Corsair celebrated its "fan week" in August, by debuting one of the most ridiculous concepts ever put into production—an oversized 500mm LL RGB fan that's 10 times the size of its industry counterpart, and with stats we can only surmise (expect static pressure and RPM to be low).

The company released a parody video of it working, complete with RGB lighting with the tag line "Bigger fan = Bigger Cooling". Although the actor misunderstood the direction in which the fan blows air, it's nice to see the company not taking itself too seriously.

Corsair has confirmed the 500mm LL RGB fan won't be going into production, and that it was a very late April fools video. **–ZS**

EVGA's Soldering Killed RTX 3090s

Following recent reports of multiple GeForce RTX 3090 graphics cards biting the dust while people were playing Amazon's *New World* MMO BETA, EVGA launched an investigation into the possible reasons for the failures and has now shared the results with PCWorld (https://bit.ly/PCW3090).

After analyzing the 24 deceased GeForce RTX 3090 graphics cards, the company discovered that the issue was down to 'poor workmanship', with some of the soldering around the graphics card's MOSFET circuits not up to the required standard.

EVGA claims that the soldering problem only affected a handful of GeForce RTX 3090 graphics cards and that all of these were part of an early production run in 2020. Although it didn't reveal exact numbers, the company confirmed that the affected batch amounts to less than one percent of all the graphics cards that it has sold. **–ZL**

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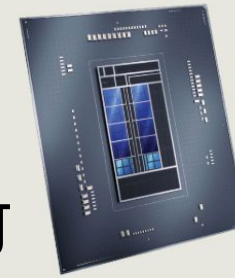
Jarred Walton

TECH TALK

PCIe Gen5 Is Coming



Intel's Alder Lake may support PCIe Gen5, but most consumer motherboards will stick with Gen4.

LAST ISSUE I talked about the upcoming switch to DDR5 memory for the next generation Intel and AMD platforms. Now, I want to talk about something we won't see with AMD's socket AM5, and most likely not on Intel's LGA1700 Alder Lake CPUs either—at least, not on consumer parts. The specifications and requirements for PCI Express 5.0 are complete, and AMD and Intel will be supporting the tech soon enough, but initially only on data center hardware.

Before anyone gets too upset, let's talk about the reason behind the decision. PCIe signaling keeps getting faster, which requires tighter tolerances. Gen3 ran at a paltry 8 GT/s per lane (985MB/s to be precise), yielding a maximum throughput of about 16GB/s for an x16 slot. That's fast enough for a lot of use cases, including gigabit Ethernet and even 10Gbps USB 3.2. The ubiquitous PCIe Gen3 now handles audio, USB ports, networking, and all the x1 to x16 expansion slots. The requirements are low enough that it's possible to route all the motherboard traces to the further slots, and the power requirements are relatively tame.

Those last two items are the real problem with future PCIe standards. PCIe Gen4 effectively doubled the per-lane performance to 16 MT/s, and PCIe Gen5 doubles it again to 32 MT/s. Building the hardware that supports the standard is a different matter. Many laptops still omit Gen4 support entirely due to power requirements, and even those that do support the standard might only provide four lanes for the graphics chip (Tiger Lake-U), sticking with slower and less power-hungry Gen3 for storage and other devices. On the desktop, AMD's X570 chipset can support Gen4 on all PCIe links, but the B550 only supports Gen4 for the GPU and primary M.2 slot, and some boards don't even provide that level of support.

> The costs of Gen5 mean we're unlikely to see support on client solutions in the next year

The issue with Gen4 is that it requires better signal quality, which means using better materials and/or thicker traces for the routing, more layers to the motherboard PCB, and potentially the use of retimers. That's why cheaper motherboards often skip Gen4, even if the chipset and CPU technically support it. And with Gen5, all those requirements become even more stringent.

PCI-SIG doesn't list an official length for Gen5 traces, and materials and other factors come into play, but one source described them as "short as hell." Signal noise becomes a much bigger factor, and to overcome that may require multiple retimers on each link, especially for slots that are farther away from the chipset and CPU. That in turn requires more power and more cost, leading us to the current plans for the next-generation platforms.

AMD's socket AM5 won't have Gen5 support for the initial Zen 4 release, while AMD's EPYC Genoa server chips will support Gen5. It's a matter of target market as well as budget. Where we used to see lots of good quality, high-end motherboards in the $150 range, similar quality boards today cost $250–$300, and top-end boards reach $500 plus. Intel's Alder Lake plans are less clear. The CPU may support Gen5, but that appears to be mostly for servers and data centers. Sapphire Rapids (Xeons) and Alder Lake (12th Gen client) use the same core logic and support Gen4 and Gen3 as well as Gen5, but the costs and requirements of Gen5, plus validation, means we're unlikely to see support on client solutions in the next year.

It's probably for the best. We have only seen widespread Gen4 support on client products, such as graphics cards and SSDs, in the past year, and most PCs don't need even Gen4 speeds. We're a long way off from saturating Gen4 bandwidth for client workloads, but data center and supercomputer needs are far ahead of home users.

PCIe Gen5 support already exists on some server chips, and looking ahead, PCIe Gen6 doubles bandwidth yet again, aided by the adoption of PAM4 signaling (4-level pulse amplitude modulation) as well as forward error correction.

At 64 MT/s per lane, a single x1 Gen6 connection could carry as much data as a x16 Gen2 link. Our home PCs will get there eventually, but probably not until a couple of years after the servers running future exascale supercomputer installations. All hail Skynet.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Ian Evenden

TRADE CHAT

Dear Microsoft: please don't mess this up

ANOTHER MONTH GOES BY and there's no sign of a crack in the weird wall of silence around Windows 11. As I write, it is exactly one month before the newly announced official release date for Windows 11, yet from the state of the preview builds—both dev and beta—you wouldn't know it.

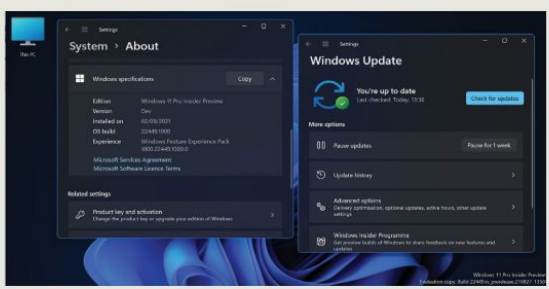
Of course, the builds are perfectly stable, but they are Windows 10 with a facelift. To distinguish itself, Windows 11 needs more than stringent hardware requirements, rounded windows, and some rather gorgeous desktop backgrounds. It needs features. And as yet, we haven't got them.

A while ago, Microsoft contacted dev channel insiders, imploring them to move onto the beta channel because some wobbly builds were coming. Could this be the Amazon App Store and the Intel Bridge tech that makes it work? The implementation of DirectStorage? So far, neither of those have raised their heads above the parapet.

By the time you read this, Microsoft may have announced these features and we'll be running Android apps and wondering what all the fuss was about. But it's only a month until the release date. That's not much time to get feedback and fix bugs.

The official announcement has a carefully worded section about "continuing our journey to bring Android apps to Windows 11" that will "start with a preview for Windows Insiders over the coming months". So no Android apps at launch? It's starting to look like a number of recent high-profile game releases, where a barely functional product is launched then receives a patch to add features and fixes that should have been there from day one.

Still, at least there's a new PC Health Check app that will tell you if your PC can run Windows 11 or not, as well as a loosening of the hardware restrictions to include some Kaby Lake CPUs. Specifically, the one that MS sells in the Surface Studio 2, by some coincidence.



With release due shortly, we need more than just a gorgeous desktop.

> The launch of Windows 11 could go down in history for all the wrong reasons.

Greater minds than ours have ascertained that the harsh cutting away of CPUs older than about four years has something to do with MBEC, or Mode Based Execution Control. This is the tech that allows the mitigations for the Meltdown and Spectre exploits to run without slowing down your PC, and it seems MS wants those bad old days well and truly forgotten.

The story changed at the end of August: you can install Windows 11 on CPUs that aren't on the official list if you do it from an ISO. You won't be eligible for an upgrade through Windows Update, but you can take matters into your own hands. Will these machines continue to get Windows 11 updates, or be cut off? MS makes no guarantees, but a raft of PCs with security holes caused by installing a newly released OS and then not patching it would be a dreadful thing to set loose on the internet.

It's the beginnings of a mess. An OS launching without headline features, a hard security cutoff that might not be anything of the sort, and a whole new OS where an update to Windows 10 might have done. Unless there's something MS isn't telling us, the launch of Windows 11 could go down in history for all the wrong reasons.

Ian Evenden's first PC was a 286 with 640kb of memory. And who could need more than that?

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THE LIST

MAXIMUM PC'S FAVORITE BUILDS

8 $300 BUILD CHALLENGE

This might be a surprising favorite. Why? Well, it's $341 for an Intel system, in stock and affordable. Budget rig, complete with dual-core Pentium G440 processor, 8GB DDR4 @2400 and 275GB of SSD.

7 COUCH POTATOES

Another console killer, the Raijintek Ophion Evo housed an AMD Ryzen 3 3100, and a Sapphire RX 5500 XT. Super clean and beautiful too—and, at just over $1000, pretty affordable.

6 COMPACT COMPUTING

Built inside the NZXT H1 chassis, this tiny bundle of fun packed a Ryzen 9 3950X, 64GB of DDR4, 2TB of PCIe 4.0 SSD, and an RX 2080 Super. And it didn't set on fire (although some did).

5 MONOCHROMATIC PERFECTION

The ultimate black and white build. Complete with Noctua Chromax fans, white Asus GeForce GTX 1060, and Intel Core i3-8350K. Surprisingly unaffordable at $1,916, but still stunning.

4 ULTIMATE UPGRADE

SLI'd MSI GeForce RTX 1080s look epic. Black, red and white color scheme throughout the NZXT S340 Elite. Easy-to-build, complete with pre-binned Core i7-6700K and 2.25TB of SSDs.

3 PURPLE HAZE

Sleek glass chassis, complete with stylish purple lighting, thanks to G.Skill and NZXT. Reference RTX 2070 Super makes the whole thing pop, and a Ryzen 5 3600X processor keeps it nice and powerful too.

2 AIR SUPREMACY

Beautiful open-air chassis. Easy to build, and unique design. Core i5-10600K, and Zotac GeForce RTX 2080 Super. Cool too, thanks to the Noctua NH-L9i cooler.

1 THE PINK PARIAH

Epic liquid-cooled build inside the Phanteks Evolv Shift X. Designed as a console killer, it was fun to create, but a nightmare to fill and drain. Incredibly hot with a Ryzen 5 2600X and GeForce RTX 2080.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Reuse components
> Win11 sleep issues
> Convert to GPT

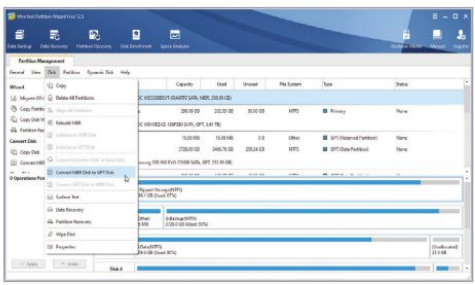
Cannibalizing old components

I've been a subscriber since 1998 and have some components lying around I'd like to reuse. I would like to consider utilizing some or all of the following components: a Rocketfish RF-FULLTWR Aluminum Full-Tower Case (huge, great reviews and mod-able), a barely used 700-watt OCZGXS700 PSU, and a new A8-7670k CPU I bought as an impulse buy four years ago (along with a mobo I can no longer find).

Alternatively, I have a new ASRock 775Dual-Vista 775 MB mobo I could build a system around, but my first thought is to use the A8 CPU, case, and PSU for a server build. I also have an ASUS U3S6 PCIe4 x4 card that offers USB 3.0 ports.

I found a review from 2016 where the processor was purchased for a small home virtualization server and was capable of handling Plex in conjunction with a repurposed Radeon gaming card, making it capable of handling simultaneous playback and transcoding to multiple devices in HD. It was also very quiet and capable of mild overclocking. It was described as an "awesome budget CPU" for utility/workhorse purposes. Would that review still apply today, or can I use the case and PSU in an all-new build? Your thoughts would be appreciated.

—Dean Johnson



Minitool Partition Wizard makes conversion to GPT easy.

THE DOCTOR RESPONDS:

That's quite an eclectic mix of components, Dean. Your first thought is a good one—ditch the ASRock mobo, which is too old, and look at pricing a system around the A8-7670k CPU instead. That is easily powerful enough for server and Plex duties, without needing a secondary graphics card, particularly if you optimize your media (see MPC Dec 2019) to minimize the need for transcoding.

You'll need to source a compatible mobo and RAM, it will need to be a Socket FM2+ and we recommend the A88X chipset. ASUS's A88XM-A/USB 3.1 ($130 new from www.newegg.com, or $80 refurbished).

The board supports up to 64GB DDR3 RAM across four DIMMs, and a compatible 16GB kit (2x 8GB) costs $76 from www.crucial.com (use its memory finder to search for 'A88XM-A/USB 3.1' to pick out matched RAM). This should be ample for your server needs, and there are still two spare slots available to add more, should you need them later.

It also has six onboard SATA ports, which gives you plenty of scope for storage. Look to populate these with NAS-optimized drives, such as Western Digital's Red range—consider a WD Red SSD boot drive for extra responsiveness—500GB would cost you around $90.

There are six accessible USB ports (2x USB 3.1, 2x USB 3.0 and 2x USB 2.0) with scope to add further USB 2.0 and USB 3.0 via internal connectors. Your PCIe USB 3.0 card would fit the board but is likely to be redundant. However, it's there if you are still short of rear USB ports.

Finally, in your email, you touched on FreeNAS as a possible server OS. Instead, the Doc suggests you check out our NAS server feature (MPC Apr 2021), where we recommend Ubuntu Server instead. This is more universally supported, can be configured to run headless via the web-based cockpit UI, and is perfect for your server needs.

Monitor upgrade query

Big fan of your magazine. Windows 11 is coming, and this means a new PC—no problem. I have two 10-year-old 27-inch Dell displays—no problem. My eyes... now that's the problem. I've been looking for 32-inch displays and found the BenQ PD3200U, but it's five years old. I don't

© MINITOOL PARTITION WIZARD

↘ submit your questions to: doctor@maximumpc.com

play games, just use it for Excel, email, YouTube, etc. Can you recommend something equivalent to the BenQ, but a little more future-proof?

—Derek Lane

THE DOCTOR RESPONDS: The original release date of a monitor isn't necessarily something to worry about, Derek. Monitor technology doesn't evolve at the same rapid pace as PC tech, and given your modest requirements, there's little point splashing out for cutting-edge features you'll never need.

Ideally, what you need to do is visit a local store and test the monitors on display, to see how your eyesight perceives the picture on them. This should be your primary thought when choosing a screen.

The key drawback with the PD3200U is that it only supports HDMI 2.0 and DisplayPort 1.2. These technologies are fine for everyday use but have been superseded by HDMI 2.1 and DisplayPort 1.4 respectively.

The latter offer greater bandwidth, so if you're planning to futureproof your purchase with one eye on greater refresh rates (which may help with your eyesight), then an updated version of the PD3200U is BenQ's EW3280U. At around $700, the price is identical, and you get one DisplayPort 1.4 and one USB-C port in addition to two HDMI 2.0 ports. It's an IPS display too, so works well in all lights. See www.gamesradar.com/benq-ew3280u-review for a full review.

If you can get to test them in a live environment, consider its cheaper little brother, the EW3270U. It's the same size but costs just $400. The key difference is that it's a VA, rather than an IPS panel, so best suited to dimmer environments. But given the potential saving, it's worth checking both out if you can.

Windows 11 sleep problem

I've recently encountered a sleep problem in both Windows 10 and 11. I've been bouncing between Windows 10 and successive Insiders Builds of Windows 11 to check my 2018 Skylake X system could run Windows 11. On my first attempt, I discovered an error with Cyberlink Power DVD 20 telling me I didn't have a valid graphics driver. I've tried it three times and followed instructions given to me by Cyberlink, but it didn't work, so went back to Windows 10.

This has happened on subsequent tests of new Insider Builds, even after switching from Cyberlink to Nero 14 Blu-ray. I then started getting errors in Windows Live Mail when clicking links, so I rolled back to Windows 10 from an Acronis backup and then found a new build of Windows 11. I installed and everything was working okay... or so I thought. Now, I find whether I'm running Windows 11 or Windows 10, that when I put the computer to sleep it appears to do so before shutting down completely after three seconds.

I've tried a recent BIOS update and tweaking the only setting related to power in the BIOS, but no luck. No luck either with any combination of power settings in Windows via the Control Panel. It's only a minor inconvenience, but I want to keep my PC off or asleep when not in use. Any help would be appreciated.

—Phillip Tursky

THE DOCTOR RESPONDS: The sleep problem may be linked to the Intel Management Engine driver. This may have been wiped out by a generic Windows 11 driver that doesn't work with your 6th generation CPU. You could try reinstalling it via www.intel.com/content/www/us/en/download/19406/ (remove the current version of IME via Device Manager under System devices, then install the downloaded driver),

However, given that Microsoft has announced that Windows 11 won't be supporting Sky Lake processors, the best thing to do is reinstall Windows 10 from scratch. Given all the switching between Windows 10 and 11, you've probably garbled parts of your current installation. Rather than try to unpick them, we recommend removing all traces of Windows 11 from your system.

If your Acronis backups go back far enough, roll back your PC to the point in time before you first attempted to install Windows 11. This may be sufficient to wipe out all those changes and restore the sleep function to its proper working condition.

If not, follow one of our recent reinstall guides to back up, wipe your Windows 10 partition and then reinstall Windows 10 from scratch using the latest version of Windows 10 as offered by the Windows Media Creation tool (www.microsoft.com/software-download/windows10).

Once Windows has been restored and you've verified things are working correctly again, do not continue experimenting with Windows 11 Insider Builds. While you may have been able to install Windows 11 successfully on your Sky Lake system, unless Microsoft has a sudden change of heart, you'll be getting no official support going forward.

Secure Boot query

I'm in no rush to get Windows 11, but I do need some help. I have the necessary hardware spec, an ASUS TUF GAMING X570-Plus and AMD Ryzen 7 5800X, but Microsoft's upgrade tool keeps telling me I don't have Secure Boot set up. I've done some sleuthing and suspect two things are holding me back: first, I need to have my drives all use GPT instead of MBR, which requires the mbr2gpt tool from the command line. But since I followed a site to bypass login, I can't boot to the command line at startup. Please help!

—Kirke Holmes

THE DOCTOR RESPONDS: The fact you've bypassed the login screen won't prevent you from converting to GPT, because mbr2gpt should ideally be run from the Windows rescue (PE) environment, which means creating Windows installation media using the Media Creation Tool from www.microsoft.com/software-download/windows10 (a USB flash drive is much quicker than DVD).

That said, you can convert MBR drives to GPT without having to go near the command line. MiniTool Partition Wizard Free (www.partitionwizard.com) is capable of performing this task. Make sure you select the entire disk rather than just a partition on it, then choose 'Disk → Convert MBR Disk to GPT Disk' and follow the prompts. Before doing so, take a full drive image of the disk using a tool such as Macrium Reflect (www.macrium.com/reflectfree) in case something goes wrong.

You shouldn't need to convert all your disks to GPT, just the disk(s) containing your Windows drive and any relevant boot partitions. Once done, navigate to the UEFI BIOS Utility, switch to the Boot section, and disable CSM. Next, set Secure Boot to 'Windows UEFI Mode', save your changes, and exit, and Windows should boot as normal. When you next run the upgrade checker, you should be clear to install Windows 11 when it's out.

Finally, if you want to restore the login prompt, press Win + R, type 'control userpasswords2', and hit Enter. Make sure 'Users must enter a username and password to use this computer' is ticked and click Apply followed by OK. When you next reboot, the login prompt will be restored.

SILENCE OF THE FANS

Fans are so last year, right?

COMPUTERS CAN BE NOISY so and so's, can't they? Whether it's the high-pitched whine of an AIO pump, the whirr of an HDD, or the roar of a gaming laptop's fans, we've all heard the effects of systems trying their best to mitigate heat. Thermal design has come a long way in the past few years, with each new generation of components producing less waste heat for the level of performance on offer.

Heat management is still an important business. If you're into overclocking, or use your system for resource-intensive tasks that put components under duress, you'll need a serious cooling solution. That means fans; usually lots of them. Case fans, radiator fans, CPU fans, GPU fans... even motherboards can now pack tiny fans for keeping your SSD cool.

Of course, those fans make noise, and the more fans you've got, the noisier it gets. So what happens when you don't have any fans at all? That's right, we're going back to the dark ages and building a fully passively-cooled PC. Not only will this machine have no fans, but we're also aiming to make it completely silent, so no HDDs allowed either. From pressing the power button to running stress tests, we don't want to hear a peep out of this PC.

How will we do this? A case with the potential for good airflow is the place to start, allowing for better passive convection of warm air out of the case. We'll also need a chunky passive cooler for our CPU, so thanks to Noctua for hooking us up with one. What else will we be using? Read on to find out.

INGREDIENTS

PART		RRP	STREET PRICE
CPU	Intel Core i5-11600K	$272	$286
RAM	16GB (2 x 8GB) G.Skill Trident Z Royal Elite DDR4-3600	$185	$185
MOBO	Asus TUF Gaming B560M-Plus	$150	$150
SSD	Samsung 980 Pro M.2 SSD	$150	$130
PSU	Seasonic PRIME 600 Titanium	$190	$250
COOLER	Noctua NH-P1	$110	$110
CASE	Cooler Master Masterbox Q500L	$60	$60
TOTAL		**$1,117**	**$1,171**

PRICES CORRECT AT THE TIME OF PRINTING

STEP-BY-STEP BUILD GUIDE
PG 24

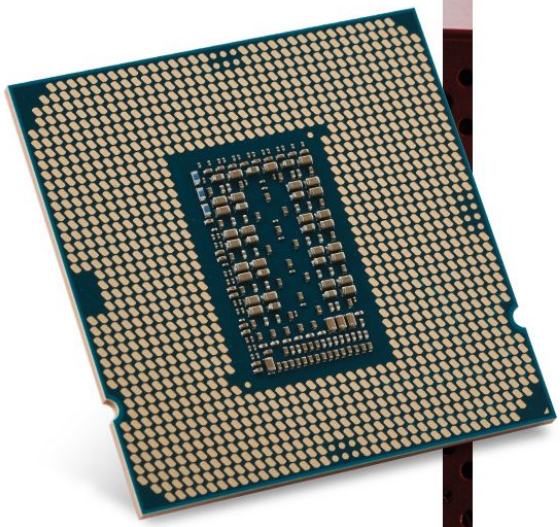
HARDWARE

MOTHERBOARD

Asus TUF Gaming B560M-Plus

RRP: $150 / street price: $150

A straightforward B560 motherboard with an mATX form factor for easy installation. The militaristic TUF branding might not be to everyone's taste, but we like these chunky heat sinks. It has got both DisplayPort and HDMI ports to support our integrated graphics, too. asus.com



PROCESSOR

Intel Core i5-11600K

RRP: $272 / street price: $286

One of the best midrange CPUs on the market right now, the Core i5-11600K has mercifully been holding steady close to its RRP. It has everything we need for this build; PCIe 4.0 support, integrated graphics, and a speedy 4.9GHz boost frequency. intel.com

CPU COOLER

Noctua NH-P1

RRP: $110 / street price: $110

This is the part that makes it all possible. Noctua's new passive cooler is a bit of a beast, barely fitting inside our case. It needs that bulk though, the NH-P1 has plenty of aluminum fins to better dissipate heat without active airflow. The SecuFirm2+ mount allows for compatibility with most modern CPU sockets. noctua.at

MEMORY

16GB (2 x 8GB) G.Skill Trident Z Royal Elite DDR4-3600

RRP: $185 / street price: $185

That's right, folks: we've got some seriously flashy memory in for this build. G.Skill's Trident Z Royal Elite drops the kitschy engraving of the original Royal RAM for a crystalline textured finish while keeping the RGB lighting. It's got some great performance behind it too; this memory is available up to a staggering 5,333MHz, but we're sticking with the more sensible DDR4-3600 version. gskill.com

POWER SUPPLY

600W Seasonic PRIME 600 Titanium Fanless

RRP: $190 / street price: $250

Most 'fanless' power supplies are in fact not truly fanless; they merely have a zero-RPM option available, usually via a physical switch on the back of the unit that manually deactivates the fan. Seasonic's PRIME 600 Titanium Fanless lives up to its name, though, with no fan and a perforated casing that allows built-up heat to more easily dissipate. seasonic.com

STORAGE

Samsung 980 Pro M.2 NVMe 500GB SSD

RRP $150 / street price: $130

With an 11th-generation Intel processor and a B560 chipset mobo, we have full access to the almighty power of PCIe 4.0. We're taking advantage, naturally, with a shiny new Gen4 SSD from Samsung, the 980 Pro. This gives us 500GB of crazy-fast storage, with maximum potential transfer speeds of nearly 7GB/s. This drive doesn't have an integrated heat sink, but that's okay because the TUF motherboard has one built-in. samsung.com

CASE

Cooler Master Masterbox Q500L

RRP: $60 / street price: $60

Thanks to its fully perforated chassis, the Masterbox Q500L is an ideal choice for this build. Passive convection capabilities are a must-have here since we won't be using any fans whatsoever. The Q500L also has a moveable front I/O panel, PSU bracket, and rubberized feet that allow for a variety of orientations. coolermaster.com

A QUIETER PLACE

How well will our silent system run?

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

1 FILTERED OUT

WE'LL START BY STRIPPING DOWN this case. Unusually, a lot of what we remove here won't be going back into the build when we're finished; most notably the dust filters, as zero fans means zero airflow, and therefore near-zero dust intake. Removing them will help with natural convection, thanks to the Masterbox Q500L's heavily perforated outer frame. Two of the dust filters are magnetic, while the third is held in place with rubber pegs. You will also need a screwdriver to remove the window and the metal side panel, then the two SATA drive mounts (we won't need these), and the PSU cage. We'll be using this system on its side, as shown, so we also removed the four feet, which are secured via plastic push-pins. If you'd rather run your machine upright, leave these in place.

4 ADAPTABLE MOUNTING

LIKE ALL OF NOCTUA'S excellent cooling solutions, the NH-P1 comes with a variety of brackets for installation on different motherboard configurations. We'll need the LGA 1200 Intel bracket, which is clearly labeled. To install this, fit the Intel backplate on the underside of the motherboard as shown by the instructions, then flip it over to put the black plastic risers on each screw mount. Once the risers are in place, add the two mounting bars so that they curve outwards from the CPU socket, and secure them with the provided thumbscrews. These can be tightened with the NH-P1's included screwdriver, which you will also need to install the cooler itself. Ensure that the brackets are secure without any wobble, but don't over-tighten the screws as you could risk damaging your components.

2 FAN DOWN

THE NEXT THING TO REMOVE is the Cooler Master case fan that comes pre-installed in the Q500L. This is a fairly simple affair; just unscrew the fan at the four corners and lift it out of the case. Be careful here, as a slip of the screwdriver could lead to a nasty scratch on the case's metal exterior and we don't have dust filters to cover that up. We recommend keeping the fan in the case box (or with any other spare fans you have) so you don't lose it. If you want to leave the fan in place for optional use, you can—just remember to turn on the zero-RPM settings in the BIOS later on. You won't be able to reinstall the fan once the cooler is in place, so it's better to make this decision now.

3 PROCESSOR PROBLEMS

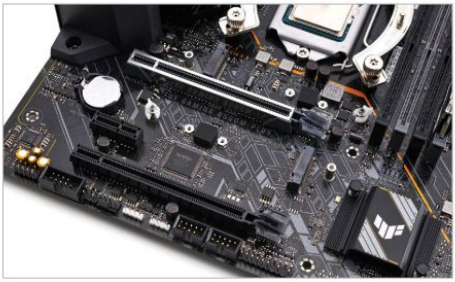
OVER TO OUR MOTHERBOARD and processor. Unbox your components and place the motherboard either on an antistatic work surface or the box it came in. Remember when unpacking your board that the antistatic bag it comes in only prevents electrical buildup on the inside layer; the outside can still carry a charge, so be sure to wear appropriate footwear and ground yourself by touching a metal object frequently. To install the chip, release the metal retention arm from underneath the CPU bracket, free the bracket from the single Torx screw, lift it up, then drop the CPU into the socket, lining up the markings on the corner. Once in place, lower the bracket back into position and secure the retention arm. If you bought a brand new mobo, the plastic cover on the CPU socket will snap off automatically.

5 ALL THAT GLITTERS

IT'S TIME TO FIT our beautiful (or hideous, depending on your taste) memory. Thankfully, this is a fairly straightforward process; release the plastic clasps on the DIMM slots, and line up each stick of RAM using the divot in the middle of the socket. Push these firmly down at both ends until the clasp shuts and the memory clicks into place. For optimal memory performance, Asus recommends using slots A2 and B2, which are the second and fourth DIMMs from the CPU socket respectively. Helpfully, these are easy to spot; not only are they labeled directly on the PCB, but they are gray in color rather than the solid black of slots A1 and B1.

6 SHIELDS OFF

NEXT UP IS OUR SUPER-SPEEDY solid-state drive. To do this, remove the heat sink from the M.2 slot closest to the motherboard by unscrewing it at both ends with a small Phillips-head screwdriver. We're actually going to move the heat sink and use the slot further from the CPU, as it will be easier to access below our chunky cooler and will hopefully give the drive a bit more breathing room. Installing the drive is child's play; simply lower it into the M.2 slot at a 30-degree angle, then push it down and secure it by rotating the plastic clasp at the opposite end clockwise until it locks in place—there's not a tiny, frustrating M.2 screw in sight! Next, remove the plastic cover from the heat shield's sticky pad, and screw it back down over the SSD at both ends.



7 ALL ABOARD

IT'S TIME TO INSTALL OUR MOTHERBOARD. You'll likely need to reposition some of the Q500L's mounting standoffs to do this properly, as the default configuration is for ATX motherboards. There are three you can move, all in a row furthest away from the rear I/O port. If you're unsure, position the motherboard inside the case and see which holes are missing standoffs beneath them. You'll need an adjustable spanner or a pair of pliers to unscrew these unless you have the right size of hex socket driver. Once your standoffs are all correctly aligned, lower the mobo into place on the central mounting peg and line up the rear I/O before securing it with the provided screws.

8 FIN FIT

MOUNTING THE NH-P1 COOLER can be tricky, but that's mostly just down to the sheer build of this fan-free heat sink. It's a single heavy unit, so be cautious not to drop it on your motherboard, or you may hear the terrifying sound of a PCB cracking in two. Apply a pea-sized blob of thermal paste (we're using Noctua's excellent NT-H2 compound, which comes free with the cooler) to the center of your CPU, then position the cooler over it and gently push down to spread it out. The Noctua screwdriver can then be used to reach down between the chunky metal fins and secure the two spring-loaded screws to the bracket we fitted earlier. These screws stop turning once they are fully secured, so there's no risk of over-tightening here.

11 BRICKING IT

LET'S SITUATE this transparent power brick inside our case. While the Q500L's versatile design means that the PSU can be mounted in a variety of different positions within the case, we'll be sticking to the default configuration here and placing it towards the front. You should be able to see markings on the chassis where it was originally fitted; use these holes, along with the screws that held it in place to begin with, to mount it. Again, be careful here; the PSU is heavy, and dropping it could damage your motherboard. Once the PSU is secured, plug in the extension kettle cable built into the case.

12 CABLE CAPERS

WITH ALL OUR PARTS IN PLACE, we need to plug everything in. Route the cables from the PSU across the rear of the motherboard plate and through the cutouts to plug them into the appropriate sockets, securing them to the clips with cable ties as you go. We don't have many cables here, so keeping everything tidy shouldn't be hard. The same goes for our front I/O cables; there's not much to do here, simply plug in the HD audio and USB cables to the relevant motherboard connectors, along with the delicate wires for the buttons and LEDs.

9 CLIP AND CLASP

FOR THOSE AFTER A TRULY FANLESS PC, skip this step. If you like the idea of having options and are willing to set up zero-RPM modes through the BIOS, though, stick around. We've got a single NF-A12x25 LS-PWM low-noise fan from Noctua, which can be installed directly onto the cooler for a bit of powered airflow when needed. This fan is near-silent and only costs $30, making it an ideal choice for a semi-fanless machine. To install it, insert the tips of the two fan clips into 'hole set 1' on the side of the cooler above the RAM, then hold the fan against the cooler and use the clips to lock it into place.

10 POWER UP

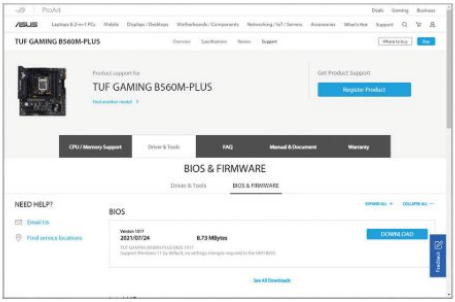
THE FINAL COMPONENT will be powering this build without so much as a whisper: Seasonic's Prime fanless power supply. This PSU's hole-covered chassis lets us see a lot more of its guts than most power supplies, which hardware aficionados may find interesting. We're more on the practical side of things right now though, so let's screw it into the PSU cage we removed from the case earlier using the included Phillips screws. It's best to also fit your power cables now, as we're running out of space to work inside the case. Fortunately, we only need two: a single eight-pin CPU power cable and, of course, the bulky motherboard ATX cable.

13 RECONSTRUCTION

IT'S TIME to put our case back together again. We're not doing much; only the metal panel and window need to be fitted, but be careful not to over-tighten the screws on the panel. Doing this will warp the rubber grommets acting as the machine's feet and might result in a wobbly PC. Store the surplus parts in the Q500L's box, in case you decide you need them later. If you've followed our optional steps to fit fans in this machine, you'll want to put the dust filters back in place too.

14 EASY FLASH

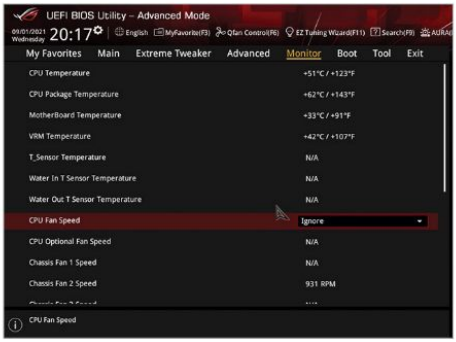
OUR PC IS FINISHED, but we're not. It's always a good idea to update the BIOS of your motherboard when you complete a build. It isn't a difficult process and helps system stability. Hop onto a different PC and download the latest BIOS firmware from the TUF Gaming B560-M Plus's support page on the Asus website, then transfer it to a blank USB flash drive. Enter the BIOS on your newly-built system and plug in the drive, then hit 'EZ Flash Utility'. Select the file and begin the update process (this should only take a few minutes). If your board is new, it should come pre-flashed; used mobos might need an older 9th- or 10th-gen Intel CPU installed first to update them for 11th-gen compatibility, so bear this in mind.



© ASUS

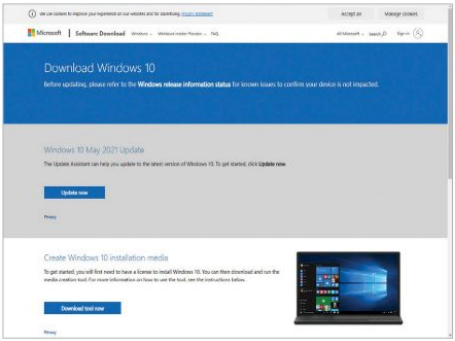
15 DEAD FAN DOWN

IF YOU'VE REACHED THIS POINT and don't have any fans installed, the motherboard will throw a tantrum and refuse to boot beyond the BIOS. This is because it's (rightfully) concerned about your CPU burning out, but fortunately, there's a solution. In the advanced BIOS settings, under 'Monitor', you can enter the Q-Fan configuration options. Here, you'll find a setting for adjusting the minimum CPU fan speed; it's set to 200rpm by default, but as we're not using a CPU fan, you can go ahead and switch this to 'Ignore'. If you are using fans, take this opportunity to adjust your fan curves and set up zero-RPM modes.



16 HELLO WORLD

WE'RE NEARLY THERE! Your last step is to install Windows 10 (or your OS of choice) on your finished system. To do this, take the USB flash drive you used earlier and wipe it, making sure it is set up with a FAT32 format. Head to the Microsoft website and download the Windows 10 Media Creation Tool to your drive, then plug it into your new PC and set it as the priority drive in the BIOS boot settings. Upon launching, you should be greeted with a guided installation process; you can proceed without a product key and activate your copy of Windows 10 later to fully unlock its features. Job done!



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THE SILENT MASTER?

IT CERTAINLY FEELS a bit strange to hit the power button on a freshly assembled build and hear absolutely nothing. It's actually not that strange, but the usual cause is that the system is failing to boot because we have a loose connection or a faulty part. Mercifully, our fanless PC booted on the first attempt, and we enjoyed the manifold pleasures of installing Windows without any fan noise to irritate us.

Before we jump into the numbers with our benchmark testing results, we feel compelled to say that this system exceeded our expectations in numerous ways. Yes, it did get pretty warm, but we were prepared for that; in a well-ventilated room, the Core i5-11600K idled around 40°C, which is considerably above average, but completely within acceptable parameters. Running the CPU at that sort of temperature for extended periods isn't likely to cause any harm to the processor.

The Seasonic Prime Titanium PSU performed even better, with thermals sitting only marginally above average. This system doesn't need anywhere close to the 600W ceiling, to be fair, so it's perhaps not surprising, but we were still pleased with its performance. We noticed an almost imperceptible whine from the PSU when the system was in sleep mode, but we suspect this was caused by the extension power cable built into the Masterbox Q500L.

Our SSD ran impressively cool, staying below 45°C even during large transfer tests; a testament both to Samsung's build quality, and the effectiveness of the M.2 heat shield included with the TUF motherboard. Overall, there was plenty to love about this build. Barring the big, heavy cooler, it was a quick and simple machine to put together, with little cable management needed after we were done. We'd call it a resounding success, but let's see those testing figures first.

BENCHMARKING RESULTS

The results were a mixed bag. The Core i5-11600K performed admirably, with little performance loss, despite the fanless cooling solution. CPU temperatures in games and benchmarks ran high, generally sitting around 80°C, but never verged into genuinely concerning territory.

The Samsung 980 Pro dominated here, pushing the limits of PCIe 4.0 to deliver blisteringly fast transfer speeds. It sat much closer to its theoretical ceiling with sequential write tests, falling short of the 5GB/s maximum by less than 100MB, while sequential reads were just a little slower, falling nearly 250MB/s short of the 7GB/s top speed. Still, these are both staggeringly fast transfer speeds that are certainly not to be sniffed at.

Graphical tests were less impressive, unsurprisingly. The UHD Xe 750 integrated graphics are decent, certainly a major step up from UHD 630, but, as you can see from our results, they fell short of offering a practical 1080p gaming experience in all but the least demanding titles. Dropping the graphical settings to minimum in *Rise of the Tomb Raider* still only produced framerates of around 25fps on average.

But 720p is an option; dropping the graphical settings along with the reduced resolution made our benchmarking games playable at 30fps, with resource-light esports titles likely to run higher. *Fortnite* and *Valorant* were playable in 1080p, with the latter maintaining 30fps at medium settings without putting too much thermal stress on the processor and memory.

1 **The NH-P1 dominates the interior of this case.**

2 **Seasonic's fanless PSU sits right against the perforated casing of the Q500L.**

3 **Our SSD nestles away underneath the cooler, but it didn't have any temperature issues.**

FANLESS GPUS?

In order to keep this build totally fanless, we had to forego a graphics card. This was a blessing in disguise at the time, because it meant we didn't have to enact a dark ritual to summon an appropriate GPU in these troubled times. If you're willing to brave the waters of eBay and do want to include a GPU, though, you have a few options here. A handful of old Nvidia GT 1030 and 1050 cards came in passively-cooled models, such as the MSI GeForce GTX 1030 2GH LP OC. These generally aren't too difficult to find used and are likely to cost you around $150.

As you can tell from our benchmark results, this isn't a system built for playing games. The GT 1030 is only just capable of playing games at 1080p, so the performance gains over these integrated graphics will be small. If you're absolutely committed to gaming on a silent rig, a more powerful option is the GTX 1650 KalmX from Palit, but these are difficult to track down. We contacted Palit to discuss the card (it is, to date, the most recently released fanless GPU), but unfortunately the manufacturer no longer produces it and currently has no plans to produce new KalmX cards.

A potential solution is to passively cool a GPU yourself, although this requires a lot more work. You could do this by water-blocking the GPU and connecting it to a large fanless radiator to liquid cool it, or potentially by purchasing a dedicated passive cooler. A small number of manufacturers sell these, such as the Morpheus II Core from Raijintek, which is compatible with cards up to the GTX 1080. Bear in mind that both of these options will require you to either buy a stripped GPU or remove the aftermarket cooler yourself.

However, the thermal performance of the overall system throughout our game benchmarking process was solid. Mainboard temperatures never ran in excess of 50°C (that's likely due to the excellent natural ventilation of the Q500L with its dust filters removed) and the case's metal outer chassis was only slightly warm to the touch even after an hour of intermittent load testing. The acrylic panel of the Q500L sits very close to the top of the NH-P1 cooler, which was a concern, but it never got too toasty. Even the cooler itself wasn't too hot to touch.

As a final exercise in sadism, we slapped Prime95's torture test on and left this machine to stew for half an hour. Did it crash? No, shockingly enough. Temperatures peaked at exactly 100°C about eight minutes in and sat there for the remainder of the test, taking roughly 12 minutes to return to idle numbers afterward. Needless to say, we were very pleased with this.

CLOSING REMARKS

Let's call this build what it was: an unmitigated success, provided you don't want tons of processing power or gaming capability. For a silent home office PC, though, this system works wonders. Solid, reliable performance without the slightest whisper of a fan was our goal, and we're happy to say that goal has been achieved.

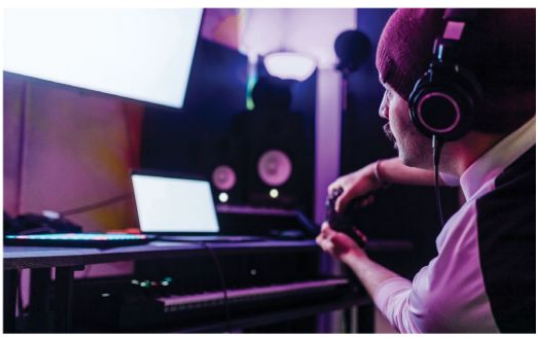
Mind you, we imagine we'd have seen a better performance with a few fans in here. Even a single case fan would likely have provided a significant boost to the cooling potential of the Q500L, creating airflow where there is currently none. We'd be slightly concerned about running this PC on a hot summer's day, too; an overcast August afternoon is one thing, but if you live in a sunny state, keep the AC on.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	1,722 (49%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	6,761 (99%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	4,911 (186%)
Rise of the Tomb Raider (fps)	60	10 (-83%)
Total War: Warhammer II (fps)	46	11 (-76%)
Tom Clancy's Ghost Recon Wildlands (fps)	39	7 (-82%)
3DMark: Fire Strike Extreme (Index)	11,101	2,168 (-80%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB Crucial Ballistix Sport LT @ 2666MT/s, an EVGA GeForce GTX 1060 3GB and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests performed at 1080p at the highest graphical profile.



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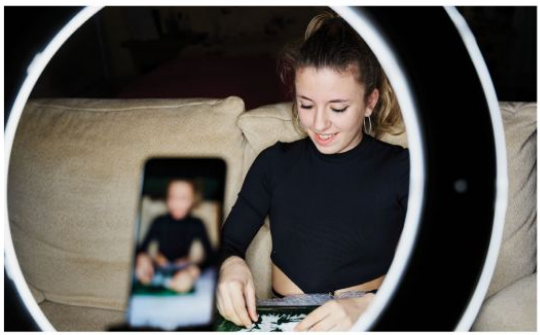


LIFE IS JUST A STREAM

Learn the ins and outs of streaming with Sam Lewis

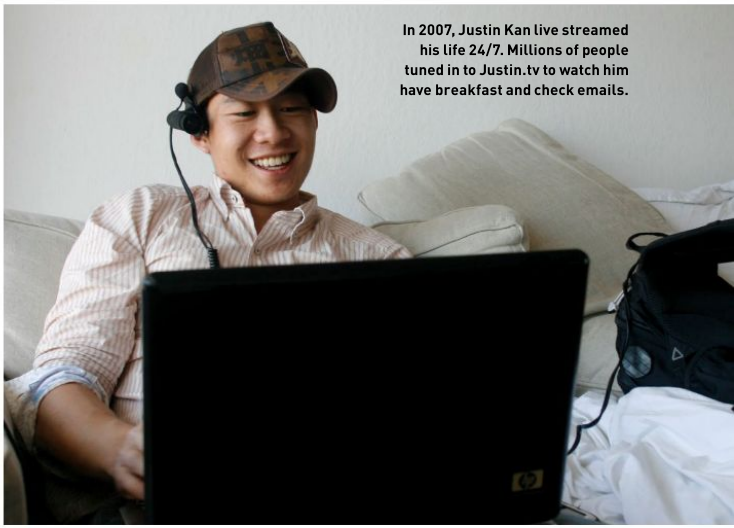
LIVE STREAMING HAS taken off in the past decade, to the point where it's now ubiquitous across many social media platforms. So what is it? Live streaming is when video or audio content is simultaneously recorded and broadcast in real-time via the internet. Twitch and YouTube remain the most popular sites, but you can also find live streaming on social media sites, such as Facebook and Snapchat.

Live streaming is a great platform to watch your favorite content and experience the anticipation you get when watching live television. Gaming is one of its most popular forms, but it isn't the only reason to get into streaming. There are all types of media you can stream: lifestyle, sports, podcasts, craft, work, vlogs, travel, music, and much more—as long as it's legal (for obvious reasons), you can stream it.

In fact, the best way to explain live streaming is that it's the internet's version of TV, only with a lot more creative freedom and the opportunity for everyone to have a go. If you have some charisma and talent, combined with a bit of luck, you can even make a living from it.

Year after year, the live streaming industry is growing in size and popularity. It is estimated that it will reach upwards of $70 billion by the end of 2021, which is pretty impressive, considering it only started to gain traction around ten years ago. Thanks to live streaming, the internet has become a great place to get the live content you're after. No longer confined to passive consumption of stuffy TV schedules, with live streaming, there is more scope for two-way communication and getting to know your favorite creators.

Community-based social interaction between the creators and the audience (or subscribers) is a big part of live streaming. The feeling of belonging to an exclusive tight-knit community has created an environment that feels far more involved than the other ways in which we consume media, including TV, cinema, or video streaming. So, over the next few pages, we'll explain all there is to know about this relatively new industry and tell you how to get started in the streaming world.



In 2007, Justin Kan live streamed his life 24/7. Millions of people tuned in to Justin.tv to watch him have breakfast and check emails.

THE IMMERSION OF TWITCH

Like many great ideas, live streaming began as a random concept that blossomed into reality. Let's go back to 2007, and a creative guy called Justin Kan. With his ideas, drive, and wacky antics, he was at the forefront of the live streaming industry as we know it today.

On March 19th, 2007, and armed with a webcam attached to a baseball cap and a laptop rigged in a backpack, Kan began to film his life. What started as a peculiar stunt soon gained traction, as people tuned in 24/7 to watch him eat, drink, sleep, procrastinate, and do his general day-to-day stuff. Now, this might not seem so crazy, but at the time, it was a genuinely new concept, if a little bizarre.

After a while, the number of viewers grew and Kan suddenly found he had an audience. On NBC's *Today* show in 2007, Kan told host Ann Curry "I'm only at the beginning of something that could be really popular." He wasn't wrong.

From humble beginnings, Kan turned his project concept into what was, possibly, the first live streaming website, Justin.tv. Kan was helped by going into partnership with Emmett Shear, Michael Seibel, and Kyle Vogt, who had created a web calendar start-up in 2005 called Kiko. Though Kiko proved a short-lived venture and was eventually superseded by Google Calendar, which was released just a year later, they had lucked out anyway, selling Kiko on eBay for $250,000.

Justin.tv was a platform that allowed anyone to broadcast video online. For the first time, viewers across the globe could follow in Kan's footsteps, by creating their own channels on Justin.tv. No longer just a channel where you could watch a grown man have breakfast, the growth of this platform brought with it a wide variety of content, as more genres and categories were created. Some of the most popular early formats included sports, lifecasting, and gaming. Justin.tv had given people an alternative to the traditional set television schedules and added some variety to their typical content consumption.

However, this expansion and a lack of control over the content brought problems for the site. With sports streaming rising in popularity, many live sporting events such as boxing, football, and soccer matches were being shown on Justin.tv for free, circumventing the TV companies and their big-money, exclusive broadcasting rights deals. Initially, this attracted millions of people to the platform, but with this came multiple lawsuits that forced the company to clamp down on piracy issues.

As the crackdown on illegal content intensified, the general interest in the website declined. In 2010, Justin.tv had 20 million annual viewers, but this dropped by 4 million the following year. Advertisers became wary of the platform too, due to the threat of lawsuits and gradually drifted away too. After all of these problems, Justin.tv had fallen a little flat. Things were on the downfall for the company and it needed a spark to get it back up and running once more.

The saving grace for the company was that, despite all the negativity, the gaming section on the site had remained strong and was still growing. Kan and his team picked up on this and added some user-friendly features tweaked towards gamers to bring more attention.

They also began recruiting gamers to stream on the platform, further boosting this section. Inevitably, it outgrew the rest of the site and needed a life of its own. In 2011, Twitch.tv was created, and so what had started off as a spark ended up being the savior of the site. In turn, it revolutionized live streaming and turned out to be perfect timing for the company.

RISE IN POPULARITY

The gaming industry and scene were in a bit of a rush in the early 2010s. As gaming became more accessible than ever, soon came the rise of game recording and creating content around this topic. Playthroughs, tutorials, competitive gaming were all part of this buzz and YouTube was a great place to showcase this. Creators made great content often with commentary and a face cam of them playing through games with edits to set their work apart. What Twitch did was take this recipe, but instead of giving you the option to edit it, you play through live with an audience. The excitement of live streaming only added more buzz to the gaming scene and it soon took off.

Twitch gave content creators the ability to grow a designated audience and community. A live chat would keep the creator in touch with their audience. Twitch became a great place to watch

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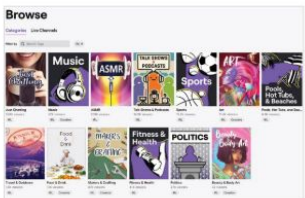
Above: **Twitch's purple logo has become synonymous with live streaming.**
Right: **With some charisma, a modicum of talent and a bit of luck, it is entirely possible to make a living from live streaming games.**
Below: **Twitch has kept on top of the live streaming game by adapting to trends.**



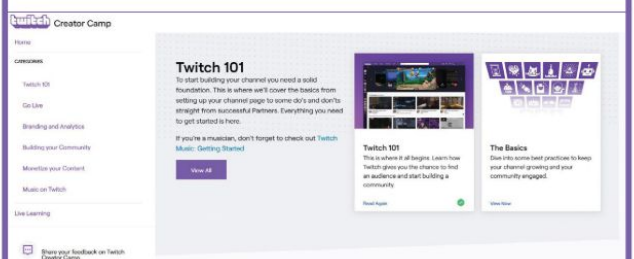
gaming content and millions of people were drawn to the platform with games such as *DOTA 2*, *League of Legends*, and *Counter-Strike*. It helped esports explode into popularity, and created a whole industry around live streaming games. By October 2013, Twitch had 45 million active viewers and, by February 2014, it was the fourth largest peak of internet traffic in the US. It doesn't take a rocket scientist to work out that they are some pretty decent figures. In August 2014, the company was bought out by Amazon for the hefty sum of $970 million. Not bad for a company that had been going just three years.

The platform has come a long way since its humble backpack rig days, with rivals such as YouTube, Facebook, and Microsoft all launching live streaming services to compete alongside it. Nonetheless, Twitch still stands out as one of the best streaming sites around.

As live streaming has become more mainstream, fueled by an ever-expanding cast of creators pulling in even bigger audiences, the diversity of the content has come full circle back to the Justin.tv days. In December 2016, Twitch IRL (in real life) was launched to cater for the growing number of vloggers using the site. Though the IRL category was later dropped, the site now also features categories such as sports, music, and chat.

However, gaming is still one of the main attractions of Twitch. Big streaming personalities over the last few years have certainly shown that you can make a living from the site, and the emergence of games such as *Fortnite*, with its competitive gameplay and live tournaments, have kept the people flocking to the site. Other titles, including *Minecraft*, *Call of Duty*, *GTA*, *League of Legends*, *Apex Legends*, and *Valorant* are still all highly watched games on the platform. It's safe to say that Twitch has come a long way over the past decade and remains a key player in the live streaming industry.

CREATOR CAMP


Creator Camp
Twitch 101
To start building your channel you need a solid foundation. This is where we'll cover the basics from setting up your channel page to some do's and don'ts straight from successful Partners. Everything you need to get started is here.
If you're a musician, don't forget to check out Twitch Music: Getting Started
View All
Twitch 101
The Basics

So, you've decided to try your hand at live streaming? A great place to start getting to grips with Twitch is through the site's Creator Camp program. From the basics of setting up to advanced tips and tricks, this informative hub has it all.

Getting your content online can be a daunting step for many novice content creators, so why not check out the Creator Camp page for some ideas on how to start and hints and tips on how to get the most from Twitch.

One of the most valuable building blocks of live streaming is to have a purpose. Twitch welcomes new viewers daily, so if you know what type of content they are looking for, it can help you build a specific stream.

Generally, four themes make a good starting point for a channel: skill, a specific game, entertainment, and social. If you can nail at least one of these, this should give you a good head start.

There's plenty more great stuff on the Creator Camp page, so head there before starting your Twitch channel.

© TWITCH

THE ESSENTIALS

WHEN IT COMES TO STREAMING, THESE PERIPHERALS WILL SET YOU OFF ON THE RIGHT PATH TO TWITCH STARDOM

Now you are up to date with the history of Twitch live streaming and understand this sector of the gaming industry better, do you still fancy your chances at becoming a live streamer? Whether you think you have what it takes to make a living from streaming, or just want to do it as a hobby, there are a few things you need to know before setting up your channel.

One of the main issues is the hardware. We know the saying 'all the gear, no idea', but the right kit can get your channel off to a strong start, giving you an advantage over the many competing for attention. Here are just some of the essential peripherals you need to start live streaming.

MICROPHONE

What good are gameplay and a facecam without any microphone audio? Your voice adds so much value to a live stream—it's how you build a character and communicate with your audience, so naturally, a mic is one of the most important parts of kit you need.

The Elgato Wave:3 microphone is a brilliant choice to let your audience hear your voice. The last thing you want is a tinny unpleasant sound and this microphone won't give you that—unless you are R2-D2.

This broadcast-grade microphone is extremely clear, plugs directly into your setup, and also has a mixer, so you can easily blend your audio sources.

- ***$150 www.elgato.com***

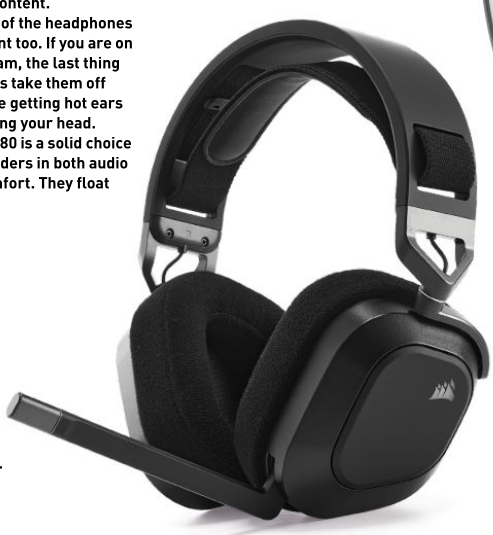
GAMING HEADSET

We know how important having a good headset is when it comes to gaming audio. If you are creating gaming content, having an extra edge with a decent pair of cans should help inspire you to produce better quality content.

The comfort of the headphones is also important too. If you are on a long live stream, the last thing you want to do is take them off because you are getting hot ears or they're hurting your head.

Corsair's HS80 is a solid choice that works wonders in both audio quality and comfort. They float on your head with the elasticated suspended headband. And their directional accuracy and high audio quality will have you playing like a pro in no time.

- ***$150 www.corsair.com***



FACECAM

We get that the internet can be a scary place, and not everyone wants to show their face online, however, most live streamers use a webcam to connect with their audience. Having a face to pair with your voice as you chat about the game you're playing is intriguing and is definitely character-building. Elgato's Facecam is one of the best webcams we have tested and is simple to set up and use. Straight out of the box, it has superb image quality and with the accompanying software, it can easily be tweaked.

- ***$200 www.elgato.com***

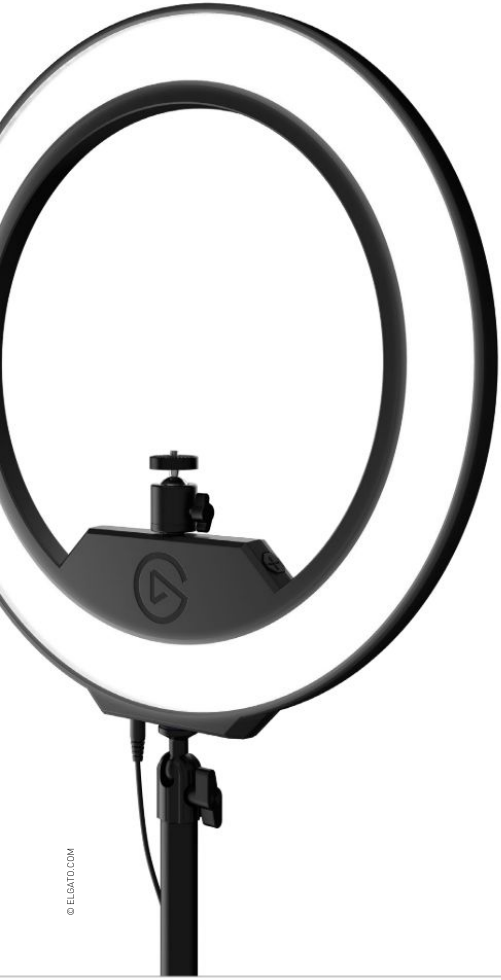
LIGHTING

Unless you are filming a night vision stream, you are probably going to need a decent light to add to your setup. As good as your content may be, your audience doesn't want to see a grainy facecam in the corner of their screen, that looks like it's shot off a Nokia from the early 2000s.

If you've chosen the Elgato Facecam from our list (see below), the good news is that it's pretty good in low-lit environments. But, like most cameras, it performs much better in a well-lit setting. So, the Elgato ring light is a great companion to brighten up your face and background.

The even, well-rounded light has adjustments for brightness levels and temperatures, so you should easily find a suitable light setting for your setup.

• *$160 www.elgato.com*



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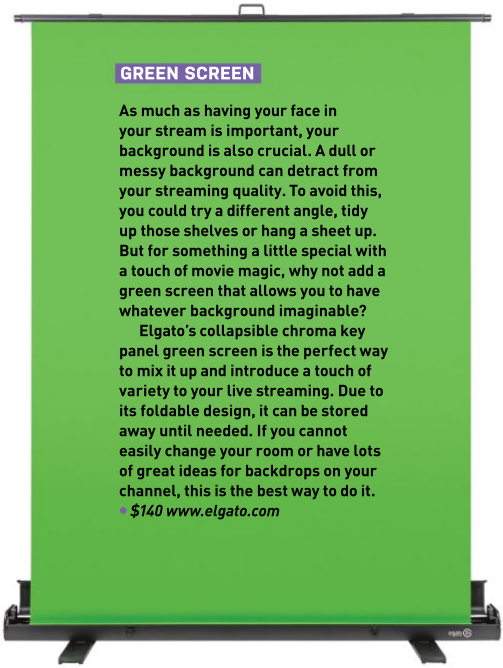


GREEN SCREEN

As much as having your face in your stream is important, your background is also crucial. A dull or messy background can detract from your streaming quality. To avoid this, you could try a different angle, tidy up those shelves or hang a sheet up. But for something a little special with a touch of movie magic, why not add a green screen that allows you to have whatever background imaginable?

Elgato's collapsible chroma key panel green screen is the perfect way to mix it up and introduce a touch of variety to your live streaming. Due to its foldable design, it can be stored away until needed. If you cannot easily change your room or have lots of great ideas for backdrops on your channel, this is the best way to do it.

• *$140 www.elgato.com*

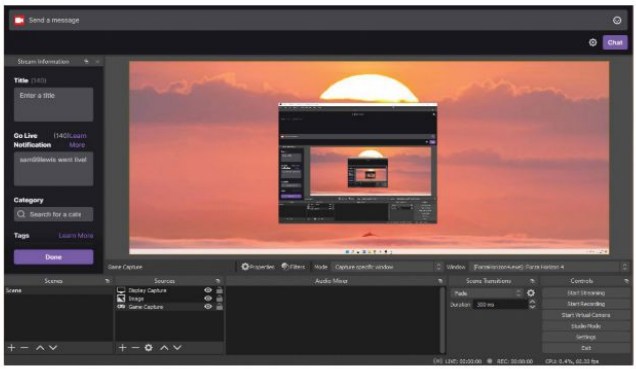
MOBILE APP

Efficiency is vital in live streaming. Being on top of time management and organization can leave you free to concentrate on creating content for your audience. Having the right tools by your side can give you more functionality and make your live streaming a much easier experience.

A traditional Stream Deck by Elgato is a great macro keyboard-like device that allows you to control some functions of your stream on the fly. The mobile app makes this process even simpler.

With 15 fully customizable buttons, you can create the perfect tool to tweak your stream in an instant. The app is completely wireless too, works on iOS 12.2, Android 6, or newer, and is a great addition to your live streaming.

• *$3 (month) or $25 (annual) www.elgato.com*



Open Broadcaster Software is one of the best ways to record gameplay on your PC

NVIDIA SHADOWPLAY

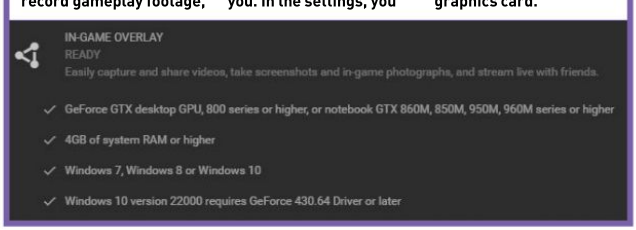
Sound too complicated? Thankfully, there is also an easy-to-use alternative to OBS. As part of Nvidia's GeForce experience game launcher app, ShadowPlay is software that allows you to stream to Facebook, Twitch, and YouTube. It has fewer settings than OBS, and though that means less control over customization, it is still a great recording program.

ShadowPlay uses an in-game overlay to record gameplay footage, whether this is live streaming or creating your own content from the footage.

There are three simple options: instant replay, record, or broadcast live. When you click one of these, it brings up more settings to suit your needs. Like OBS, you have to link your streaming accounts to be able to broadcast live straight from the app. Once done, it is simple to go live, but without the full scene customization OBS gives you. In the settings, you can create overlays, but these are much less in-depth than on OBS.

If you are starting up, have a supported graphics card, and are not sure whether you want to pursue live streaming, then Nvidia ShadowPlay is a great feature to try.

Regardless of whether you use ShadowPlay or not, Nvidia GeForce Experience is a solid application from which to launch games and to keep on top of the latest drivers for your Nvidia graphics card.


IN-GAME OVERLAY
READY
Easily capture and share videos, take screenshots and in-game photographs, and stream live with friends.
GeForce GTX desktop GPU, 800 series or higher, or notebook GTX 860M, 850M, 950M, 960M series or higher
4GB of system RAM or higher
Windows 7, Windows 8 or Windows 10
Windows 10 version 22000 requires GeForce 430.64 Driver or later

USING OBS

One of the best ways to record gameplay on your PC and stream to sites such as Twitch is through software—and one of the easiest applications to get the ball rolling is Open Broadcaster Software (OBS). This open-source free software is specifically for capturing gameplay and streaming, so once you get the hang of it, and have a purposeful stream in mind, you are ready to get started. The application is pretty straightforward and makes the process a whole lot easier.

Open it up for the first time, and you will be prompted to select between a few options: either optimize for streaming, optimize for recording or use the virtual camera. Pick the streaming option, then choose a resolution and FPS settings. On the next page, select the live streaming service you want to use and connect your account to. Once authorized, keep clicking through until you get to the opening screen of OBS.

It isn't the slickest application, but it's free and easy to use, so what more can you ask for? The most important thing when you are setting up your stream is the scenes and sources tabs in the bottom left corner of the window. A scene is like a project so you can create multiple scenes and switch between them depending on what you are streaming. These are presets that you can modify to suit your needs—one scene could be for a gaming stream and another for an IRL stream for example. You can save these to make the whole process a lot more efficient.

To modify your scenes, head into the sources tab. Here, you can add the media you want to put in your stream. To start, add your facecam and set that up how you want. The main window in the application is a live preview of what your stream will look like, so you can see what your viewers will see. To add your face into the stream, you must have a webcam plugged in already, then click on the plus icon in the sources tab.

In the drop-down menu find 'Video Capture Device' and select your webcam on the pop-up window, there will be a few settings here too, if you need to tweak anything. This will appear in the main 'scene' previewed in OBS. You can move this camera around and adjust the size accordingly. The sources tab works like a layer tab does in Adobe applications.

The top layer will appear above everything. So you want your camera on top and then you can add in your audio source. Using the same method, click on the plus icon and find 'Audio Input Capture' and select your mic. Then the next part for a basic stream is to add the content. To

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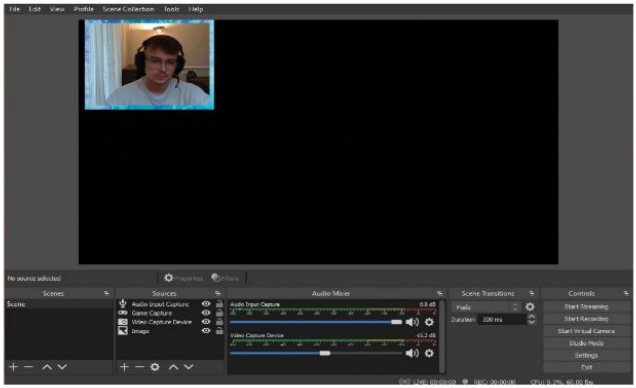

Open Broadcaster Software allows you to stream gaming content to sites such as Twitch.

record gameplay you need to click on the plus icon, then click on 'Display Capture or Game Capture' to record. Display capture records your whole screen and adds that into your scene. Game capture records a specific window that you can choose. Having both of these options makes it easy to create the right scene you need.

If you are happy with how things are going, you are ready to start streaming. As this is paired with your streaming account it will automatically get things underway for you, making this an even easier process. Linking an account helps make the software much more efficient, when linking a Twitch account you get to see the live chat in the software and you can create a title for your stream and create a live notification.

This is the basic way to get streaming but the hard work is in creating unique entertaining content, building an audience, and keeping them engaged. Streaming can be a strenuous process, with a lot of hard work involved behind the scenes, and success doesn't often come overnight. If you're thinking about starting to live stream, consider all these points and use the OBS software to create some interesting scenes.

There are plenty of tutorials on YouTube to add cool edits to your scenes. The best advice is to keep at it. If you enjoy what you are doing, then this should make it a lot easier. Finally, a useful tip is to think to yourself, would I watch this?

CAPTURE CARDS

USB CAPTURE CARD

PCIE EXPRESS CAPTURE CARD

Before software recording reached the sophisticated heights of today, video recording was predominantly done using capture cards. These are typically USB devices or PCIe express devices that can capture content from external hardware, such as a console or a camera.

These are the most commonly used cards and both need to be connected to a PC for it to handle the processing of the data. In the consumer market, most of these devices have an HDMI input for connecting to a games console.

The market is quite diverse, and there are plenty of different options available for different resolutions and different streaming needs.

If you are constantly on the go or recording from several different devices, a USB capture card is the more sensible option as this runs on most laptops with a 3.0 USB port.

However, if you have a permanent setup and want a slightly more reliable option that doesn't take up a USB slot, choose a PCIe express capture card.

This takes an unencrypted video signal and converts it into a readable format for your PC. You can then take this straight into a stream or edit the files to create custom videos.

The good thing about encryption is that it stops piracy—and no, that doesn't mean you can't capture yourself streaming *Lego Pirates of the Caribbean*, that will still work. Awful jokes aside, some sites such as Netflix, use encrypted signals using HDCP, so if you try to live stream the latest films or TV series using a capture card, it won't work.

One of the main benefits of using a capture card is the pass-through capabilities. This essential feature means that you can game and record without creating any latency issues.

Capture cards have always been an essential part of the gaming industry when it comes to content creators broadcasting gameplay. But now, they are the best route to take if you are going to live stream games, particularly if you care about latency and gameplay quality.

- ***USB capture card: Elgato HD60 $295***
- ***PCIe express capture card: Elgato Capture 4K 60Pro $250***

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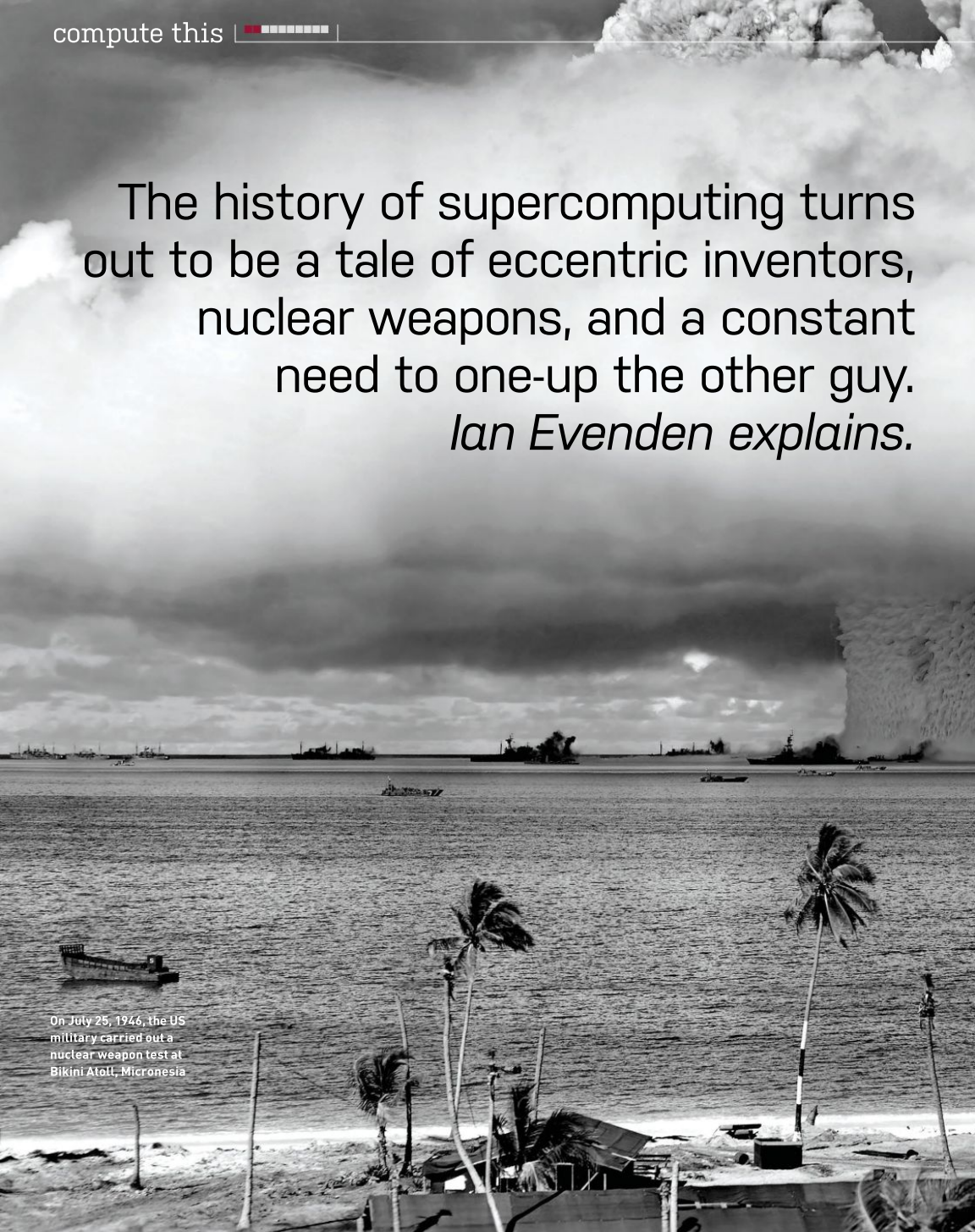
The history of supercomputing turns out to be a tale of eccentric inventors, nuclear weapons, and a constant need to one-up the other guy. *Ian Evenden explains.*



On July 25, 1946, the US military carried out a nuclear weapon test at Bikini Atoll, Micronesia

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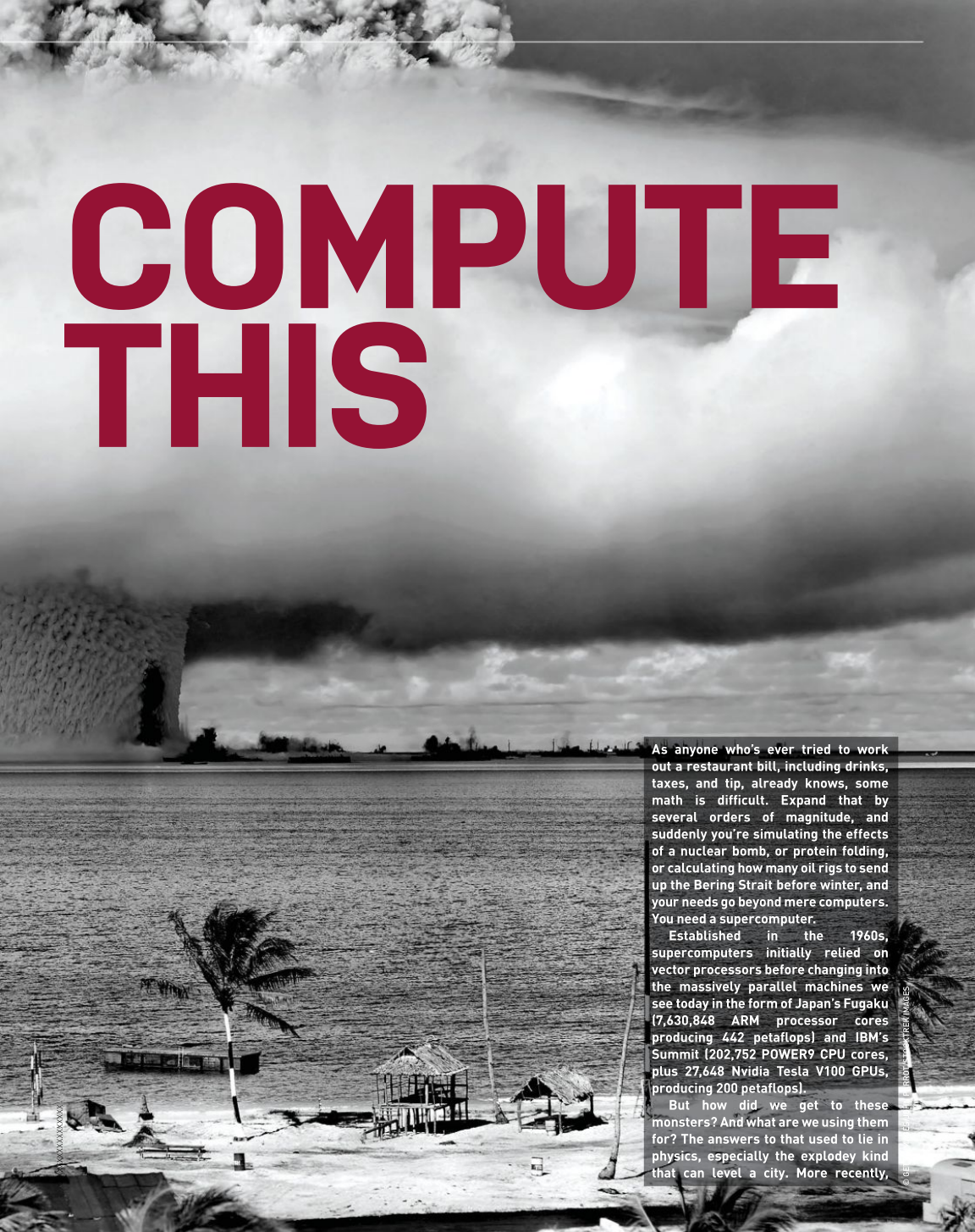


As anyone who's ever tried to work out a restaurant bill, including drinks, taxes, and tip, already knows, some math is difficult. Expand that by several orders of magnitude, and suddenly you're simulating the effects of a nuclear bomb, or protein folding, or calculating how many oil rigs to send up the Bering Strait before winter, and your needs go beyond mere computers. You need a supercomputer.

Established in the 1960s, supercomputers initially relied on vector processors before changing into the massively parallel machines we see today in the form of Japan's Fugaku (7,630,848 ARM processor cores producing 442 petaflops) and IBM's Summit (202,752 POWER9 CPU cores, plus 27,648 Nvidia Tesla V100 GPUs, producing 200 petaflops).

But how did we get to these monsters? And what are we using them for? The answers to that used to lie in physics, especially the explodey kind that can level a city. More recently,

IMAGE: FUTURE PUBLISHING VIA STAR TREK IMAGES

however, things like organic chemistry and climate modeling have taken precedence. The computers themselves are on a knife-edge, as the last drops of performance are squeezed out of traditional architectures and materials, and the search begins for new ones.

This, then, is the story of the supercomputer, and its contribution to human civilization.

DEFINE SUPER

What exactly is a supercomputer? Apple tried to market its G4 line as 'personal supercomputers' at around the turn of the millennium, but there's more to it than merely having multiple cores (although that certainly helps). Supercomputers are defined as being large, expensive, and with performance that hugely outstrips the mainstream.

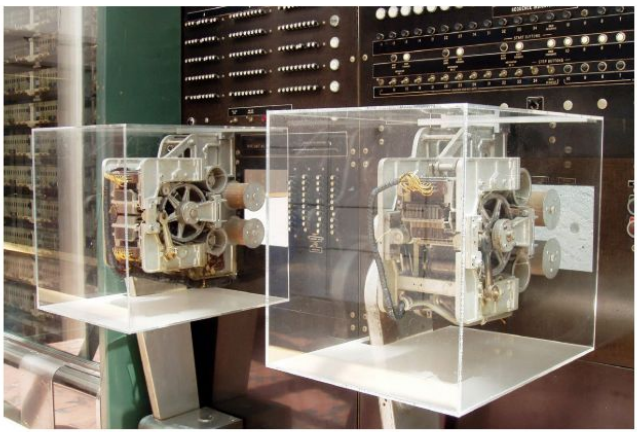
Apple's claim starts to make more sense when you compare the 20 gigaflops of performance reached by the hottest, most expensive, dual-processor, GPU-equipped G4 PowerMac to the four gigaflops of the average early-2000s Pentium 4. For context, Control Data's CDC Cyber supercomputer ran at 16 gigaflops in 1981, a figure reached by ARMv8 chips in today's high-end cell phones.

Before supercomputers there were simply computers, though some of them were definitely super. After World War II, many countries found ways to automate code-breaking and other intensive mathematical tasks, such as those involved in building nuclear weapons. So let's begin in 1945, and the ENIAC.

This programmable mass of valves and relays was designed to compute artillery trajectories, and it could do a calculation in 30 seconds that would take a human 20 hours. Its first test run, however, was commandeered by John von Neumann of the Los Alamos National Laboratory and consisted of calculations for producing a hydrogen bomb. ENIAC was programmed, and provided its output, using punch cards, and a single Los Alamos run used a million cards.

ENIAC was upgraded throughout its life, and when finally switched off in 1956 (having run continuously since 1947, pausing only to replace the tubes that blew approximately every two days) it contained 18,000 vacuum tubes, 7,200 crystal diodes, 1,500 relays, 70,000 resistors, 10,000 capacitors, and around half a million joints, all of them soldered by hand. It weighed 27 tons, and took up 1,800 sq ft, while sucking down 150kW of power. Its computational cycle took 200 microseconds to complete, during which time it could write a number to a register, read a number from a register, or add/subtract two numbers. Multiplication took the number of digits plus four cycles, so multiplying 10-digit numbers took 14 cycles, or 357 per second.

The CDC 6600 from 1964 is often considered to be the first supercomputer.



Parts of the Harvard Mark I computer on display. Made by IBM, and proposed in 1937, John Von Neumann ran the first program on it in 1944 under the Manhattan Project.

Early computers owed much to the design of the ENIAC and the British Colossus. Breaking enemy codes was still a high priority, as was finding ever more efficient ways to blow things up with both high explosives and pieces of uranium. It's around the early 1960s, though, that things such as processors and memory became recognizable. Take the UNIVAC LARC, or Livermore Advanced Research Computer, a dual-CPU design delivered in 1960 to help make nuclear bombs, and the fastest computer in the world until 1961. The LARC weighed 52 tons and could add two numbers in four microseconds.

TECH EXPLOSIONS

There was a burst of computer development in the early 1950s. IBM had been in the game since WWII, its Harvard Mark I electromechanical machine coming online in 1944, with one of its first programs, again run by Von Neumann

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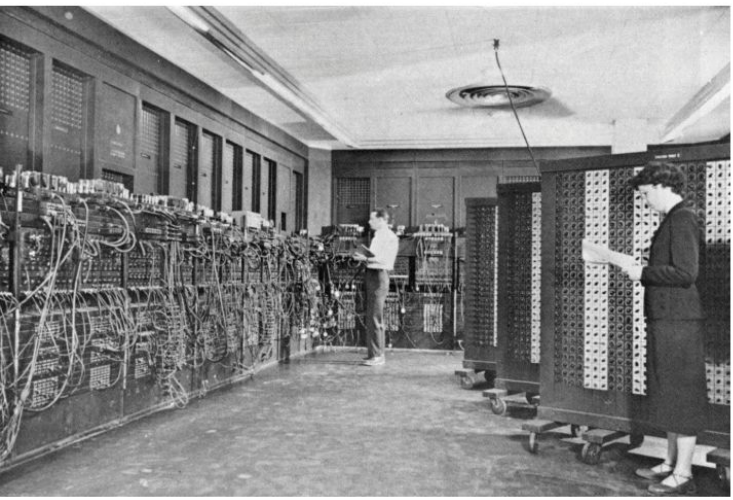

The ENIAC at the Ballistic Research Laboratory, Pennsylvania, circa 1950.

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to aid the Manhattan Project. In 1961, Big Blue would release the IBM 7030, known as Stretch, the first transistorized supercomputer and the fastest computer in the world until 1964 (a customized version of Stretch, known as Harvest, was used by the NSA for cryptanalysis from 1962 until 1976, when mechanical parts in its magnetic tape system wore out).

Von Neumann was behind another computer, sometimes named for him, at the Institute for Advanced Study in Princeton, which was in operation until 1958. This computer was the basis for a new generation, including the IBM 701, the ILLIAC I at the University of Illinois, and Los Alamos' alarmingly named MANIAC I, which became the first computer to beat a human at a chess-like game (on a 6x6 board with no bishops to suit the limitations of the machine).

The ILLIAC line would become highly influential, with ILLIAC II completed before Stretch and the open-source nature of its design leading to suspicions of 'borrowing'. Certainly, the two computers are early examples of a pipelined design, and feature heavy use of transistors instead of vacuum tubes. When faculty member Donald B Gillies programmed ILLIAC II to search for Mersenne prime numbers, it found three new ones.

The first massively parallel computer design was the ILLIAC 4 (the MkIII machine was designed to detect nuclear particles in bubble chambers, and was destroyed in a fire). Originally meant to have 256 floating-point units, and four CPUs, it could run at a billion operations a second, but due to budget constraints, only one CPU and 64 FPUs were completed in 1972. Even so, this quarter-computer still managed 50 Mflops, making it the fastest in the world. ILLIAC 4 was also the first networked supercomputer, being connected to the ARPAnet in 1975, a year before the Cray-1.

THE GENIUS OF CRAY

There's a name that shook the world of supercomputing. The whole story would be nothing without the influence of Seymour Cray, who joined Engineering Research Associates in 1951 to build code-breaking machines, but left in 1957 to co-found Control Data, and would later found Cray Research, Inc (now part of HP) in 1972. Cray was gifted, some might say eccentric (he dug a tunnel under his home, and attributed his successes to the advice of 'elves' who visited him there), and was given to spending hours in deep concentration to solve a problem. The reason early Cray machines are circular or C-shaped, for example, is so that every electrical interconnect can be the same length, so an electrical signal always takes the same amount of time to travel down each one.

In his book *The Supermen: Seymour Cray and the Technical Wizards Behind the Supercomputer*, author Charles J Murray relates this anecdote: "After a rare speech at the National Center for Atmospheric Research in Boulder, Colorado, in 1976, programmers in the

WHAT HAPPENS TO DEAD SUPER-COMPUTERS?

Judging by the speed at which old supercomputers become obsolete (their average life expectancy is three years before an upgrade), and new champions rise to the top of the speed charts, you might expect there to be a boneyard in the Nevada desert, such as the 309th Aerospace Maintenance and Regeneration Group that mothballs old military equipment.

Alas, not. Old supercomputers don't just die, they get well and truly taken apart. The ILLIAC II, for example, was disassembled roughly a decade after its construction and many faculty members took components home to keep. Donald B Gillies himself kept 12 modules, donating them back to the University of Illinois Computer Science department in 2006.

It's not unheard of for piles of Xeons to appear on eBay following the dissolution of a supercomputer or datacentre, but more regularly these days the boards are sent for recycling. "There's a lot of gold and valuable metals in there," says Levesque. "And there are people who recycle these old machines."

Sexton's experience is more brutal. "They typically get crushed," he says. "In some of our contracts, we have a requirement to crush the parts after they're done, because customers don't want people going in and figuring out what they've been doing by reading back bits and bytes in memory."

With new systems meaning more compute for the same power and the same price, there's often no need to retain old systems, keeping one around and trying to restart it is just not worth it. Typically, hardware is disassembled and the remaining pieces are broken up and crushed. "There's a lot of gold, silver, and rare earth minerals in there, and there are companies that specialize in retrieving them," says Sexton.

Deep Blue was broken up with undue haste by IBM following its victory over Kasparov, and the story of the British government's destruction of Colossus, broken into pieces no larger than a man's fist and then kept secret for decades, reminds us that these huge, complex objects have a limited useful life.

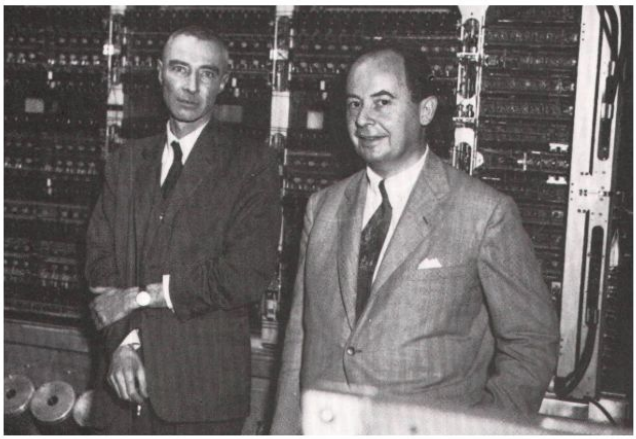
audience had suddenly fallen silent when Cray offered to answer questions. He stood there for several minutes, waiting for their queries, but none came. When he left, the head of NCAR's computing division chided the programmers: 'Why didn't someone raise a hand?' After a few moments, one programmer replied, 'How do you talk to God?'"

John Levesque, the Director of Cray's Supercomputer Center of Excellence based at Los Alamos National Laboratory (home of the Manhattan Project and much US nuclear research since), remembers him: "He was very shy. It was extremely difficult to get him to give a talk. But when he did, it was outstanding. When I met him, all I did was shake his hand. He didn't say anything."

Levesque has worked on all the greats of early supercomputing and remains in the sector today. He began his career working on the ILLIAC 4: "The UK had a machine called the DAP [International Computers Limited's Distributed Array Processor, the first commercially available parallel computer, delivered to its first customer in 1979] at the same time as the ILLIAC, and similar to it, but it didn't have the support that the ILLIAC did. I know there are a lot of people who felt it was a complete failure, because it never went into production, and they only really developed a quarter of the machine."

This wasn't Levesque's first brush with supercomputers, however. "I started working at Sandia National Laboratories in 1968. And I was working for the Underground Physics Department, and then I went to work at the Air Force weapons lab in Albuquerque for three years. Then I worked for a government contractor in 1972 in southern California called R&D Associates, and while I was there, I got a contract from DARPA [Defense Advanced Research Projects Agency, the branch of the DoD interested in new materials and ideas] to monitor ILLIAC 4 code development efforts.

"In 1976, Cray gave a computer to Los Alamos—it was serial number one—with the intent of convincing them that the machine would be extremely good for their applications. So because of the experience that my team had on the ILLIAC 4, and back to this point we probably had a team of five or six people, Los Alamos hired us to port and optimize their principal application to that Cray and so in 1977, we started working on that. We had a cross-compiler but, initially, there was no vectorizing compiler, we were using what's known as Cray vector primitives to load registers, perform operations, and store results. When Cray came out with a vectorizing compiler, we wrote Fortran do-loops that could be optimized and used vector instructions on the Cray-1."



Fathers of the atomic bomb: Robert Oppenheimer (left) and John von Neumann at the October 1952 dedication of the computer built for the Institute for Advanced Study.

John Levesque, head of Cray's Supercomputer Center at Los Alamos National Laboratory, the home of US nuclear research.

"Los Alamos was primarily using CDC 7600s [from Control Data] which were also designed by Seymour Cray", Levesque says. Peaking at 36 Mflops, the 7600 had a clock cycle of 27.5ns, for a speed of 36.4MHz on its strange 60-bit processor, and its base configuration sold for $5 million in 1967. It wasn't Cray's first successful design, the Control Data 6000 series had outperformed IBM's Stretch by a factor of three, and the 6600 was the fastest computer in the world from 1964 to 1969, when it lost the crown to the 7600.

The last of his Control Data designs was the 8600, essentially four 7600s welded together running at a faster cycle speed of 8ns; it was never released, and problems with its design and budget prompted Cray to leave the company in 1972.

He didn't go far, setting up Cray Research in the same Wisconsin town as Control Data. The Cray-1, announced in 1975, was 5.5 tons of C-shaped genius running at 80MHz, with a cycle speed of 12.5ns on the faster, inside edge of the C (where interconnects could be shorter), it was slower on paper than the brute-force power of the 8600 but made up for it with cunning design, full 64bit processing and limited parallelism for a peak output of 160 Mflops. The National Center for Atmospheric Research (NCAR) estimates it was 4.5 times faster than the 7600.

Levesque says Cray 'gave' the machine to Los Alamos, but there was a bidding war between the New Mexico lab and its rival, the Lawrence Livermore National Laboratory at the University of California, Berkeley. Los Alamos won and received the machine for a six-month trial. NCAR got one in 1977 (which it used until 1989), the NSA had one for code-breaking, possibly even before Los Alamos—a machine with serial number zero ended up in the British Atomic Weapons Establishment. In total, 80 Cray-1 machines were sold, for up to $8 million each.

VECTOR PROCESSING

The key to the Cray-1's success was its combination of all-round high performance with vector processing. Traditional scientific code was written as loops in Fortran, where the operands (the objects of a mathematical operation) were processed one at a time. Vector processing opened up the abilities of parallel computers by carrying out the same operation on multiple pairs of operands at once, making it much more efficient. The trick was to convert the Fortran loops to vectors, which could be done automatically.

"The whole idea is that the user is writing in Fortran," says Levesque. "And so the compiler has to identify where it can use a ray operation. And the logical place is in a Fortran do-loop. The compiler

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The Cray-1 supercomputer on display at the Computer Museum of America, Roswell, Georgia.

Boards from the ILLIAC 4 computer, state of the art in 1966.

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has to determine if all of the operations are independent of one another. The main thing is that each add, or multiply, or multiply add, needs to be able to be done for the full extent of the do-loop. So the compiler determines that it can do that, and it generates vector instructions. There are things like NCAR's code, which had ambiguous subscripts and was extremely difficult to vectorize because of the way they wrote their loops. Cray told them, 'You have to rewrite your loops'. And NCAR said, 'We don't have enough manpower to rewrite our code'. And so, Cray came up with the very first compiler directive, which is a common line to any other compiler. It was DIR $ I V E P, and it stood for 'ignore vector dependencies'. Once this directive was placed in front of the loops of compiler-generated vector code, it ran fast. NCAR bought a Cray."

"Then, since we had experience on the Cray, we got numerous contracts to help people with moving their code to the Cray. We struck oil in the early '80s. At that time, there was a company by the name of ARCO that had been bought by BP. And there was a fella who gave a talk at a conference who said that his solution technique could not be vectorized. And so I got the code, vectorized it, and showed him, and ARCO ended up giving us a contract to port all of their reservoir simulators to the Cray.

It was kinda interesting because one time, the guy called me up and said, 'It's very important that you have this one code

FLOPS

Computer power is measured in Floating Point Operations Per Second or flops. This number is used to compare different systems, with higher numbers meaning more power. PCs used to be given additional floating point units to help them with complicated calculations—we called them math co-processors, such as Intel's 80387 —but everything since the 486DX has had it bundled into the CPU (the co-processor for the 486SX, known as the i487SX, was a full-blown 486DX, and took over all processor functions as long as you left the original chip in place).

A floating-point number is simply one with a decimal point. That point, however, isn't fixed. Floating-point math trades range for precision (you'll sometimes see floating-point math qualified as '32-bit precision') and keeps a set number of significant digits from the numbers being juggled, then scales them by an exponent when finished to return them to their original length. This way, the large and the small can be represented by an integer of the same length, scaled by different exponents.

Konrad Zuse's Z1 mechanical computer from 1938 used 24-bit floating-point arithmetic and, until it was standardized in 1985, IBM, Cray, and other manufacturers all had their own floating-point formats, with IBM's being hexadecimal. As computers have become more powerful, the number of flops has been counted in the same way as bytes, from mega, giga, tera, peta, up to exa.

As all PCs are different, the current-gen consoles can provide a fixed point for comparison. The PlayStation 5 claims a combined figure of 10.3 teraflops, and the Xbox Series X 12.1 teraflops. Intel's first teraflop CPU was the Core i9-7980XE Extreme Edition with 18 cores from 2017, while the RTX 2080Ti GPU puts out 13.4 teraflops, a figure more than doubled by the RTX 3080Ti.

The i487SX from Intel was rather more than just a math co-processor.

running fast'. And I asked why, and he said, 'Oh, we have to figure out how many oil drilling rigs to move up through the Bering Strait before it freezes over'. And we were successful. We even gave Cray training courses on the Cray."

COOLING COMPONENTS

The Cray-1 generated a lot of heat, so its cooling system was almost as lovingly designed as its integrated circuits. Circuit boards were placed back to back, with a sheet of copper in between. This spread heat to its edges, where it met stainless steel pipes containing liquid Freon, which carried the heat away to a cooling system mounted under the C-shaped main unit.

There were two updated versions of the Cray-1, the 1S, and 1M. These had larger memories, faster cycle times, the addition of MOS RAM and even solid-state storage. The Cray itself was supervised by a second computer, Data General Supernova or Eclipse models, which fed them their operating systems (Cray OS at first, then later a version of UNIX) at boot time and could act as a front-end—these changed through the years as well. Further Cray machines, developed by a different team under designer Steve Chen ("Outgoing and personable," according to Levesque), were released, each taking their turn as the fastest machine in the world, but it wasn't until the Cray-2 in 1985 that Cray himself returned to the top.

The first Cray design with multiple CPUs, four custom vector processors, the Cray-2 used novel 3D wiring techniques and a 'waterfall' cooler that's practically a work of art, but the new design had trouble beating 1982's Cray X-MP, developed from the Cray-1, and its successor the Y-MP. Sales were poor. The Cray-3, meant to be 12 times as powerful as the Cray-2, saw Seymour Cray and his company part ways once again, with Cray research continuing to work on the Cray C90 (a development of Y-MP tech that ran at 244MHz/4.1ns in 1991) and a spin-off, the Cray Computer Company, taking the Cray-3 tech and its single customer, the Lawrence Livermore Laboratory, with it. The laboratory would later cancel its order. Cray lent the sole Cray-3 built to NCAR as a demonstrator, but bankruptcy followed.

This didn't stop Cray, whose Cray-4 scaled from four to 64 processors each running at 1GHz. A 16-processor system came with 8GB of memory, provided 32 Gflops, and cost $11 million. Nobody was buying. The company stopped work in 1994, and Cray died following a car crash in 1996, aged 71. "It seems impossible to exaggerate the effect he had on the industry," said Joel Birnham, former CTO of Hewlett Packard, in tribute to Cray. "Many of the things that high-performance computers now do routinely were at the farthest edge of credibility when Seymour envisioned them."

The Cray-2's internal wiring. And you thought your PC cables were a mess!

Left: **Jim Sexton, an IBM Fellow and Director of Data Centric Systems.**

Right: **Seymour Cray, oddly looking like a cardboard cutout, with his Cray-1 computer.**

His company would pass through a number of hands, including those of Silicon Graphics, Sun Microsystems, and Tera (which renamed itself Cray, Inc after the acquisition). Hewlett Packard Enterprise (HPE) acquired the company for $1.3 billion in 2019, and today is building the LUMI supercomputer in Finland with a theoretical maximum performance of 550 petaflops, slotting into the top five fastest computers in the world.

ONE HORSE RACE?

While Cray was dominating, others hadn't been sitting around. MIT's Connection Machine, the result of work into alternative computer architectures that strayed from the orthodoxy put together by Von Neumann, started with 1985's CM-1 which had up to 65,536 individual processors, each extremely simple, processing one bit at a time, and a striking visual design for its casing that led to many programs being written just to blink its many LEDs. The CM range ended up, in the form of the CM-5, on top of the world computer speed rankings in 1993, with a 1,024-processor machine putting out 131.0 Gflops. One even appears in the *Jurassic Park* movie (though it's a Cray in the novel). Also topping the rankings in 1993 was Intel, cramming up to 4,000 i860 RISC processors into Paragon for up to 143.4 Gflops. Fujitsu's Numerical Wind Tunnel supercomputer used 166 vector processors to gain the top spot in 1994 with a peak speed of 170 Gflops.

IBM, in particular, had been releasing mainframes and minicomputers all through the 1950s to the '80s, as well as its PC line from the 1981 launch of the 5150 through the XT, AT, and more. A lot of what are thought of as its brands are actually made by Lenovo, coincidentally also the maker of 184 of the

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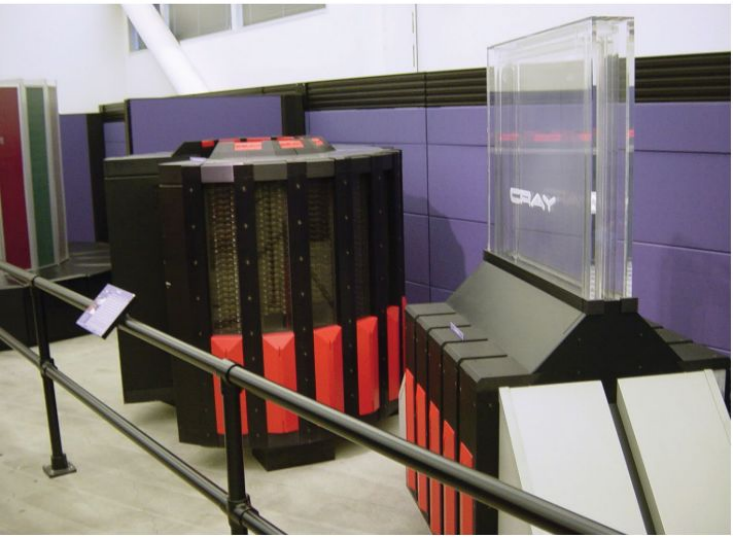

A Cray-2 (*left*) and its cooling system (*right*) on display at the computer History Museum

A Cray-2 logic module, showing the tight packing of components

top 500 supercomputers, the company to which IBM sold its PC business in 2005. Mainframes, being suited for bulk data processing, are not the same as supercomputers, which tend to concentrate on one extremely complex task at a time.

Blue Gene, and its predecessor the Scalable POWERparallel (SP) series, changed all that in the 1990s. An example of cluster computing, computers that work together so closely they can be considered a single unit, they mark the emergence of IBM's Power architecture (known to Mac owners as PowerPC G3, G4, and G5, beloved of Xbox 360 and Nintendo Wii gamers, and also trundling about on Mars in the Curiosity and Perseverance rovers).

ASCI

Nuclear weapons rear their head too at around this time, with the creation of the Advanced Simulation and Computing Initiative (ASCI), a supercomputing program to extend the lifetime of the US's aging stockpile of nukes by simulating the way a nuclear weapon will react under different conditions. Essentially, if we leave these things in the cupboard for 50 more years, will they still go bang if we want them to?

"A big change in computing came around in the early 1990s, and that was due to the Nuclear Test Ban Treaty," says Jim Sexton, an IBM Fellow and Director of Data Centric Systems at the company. "In the 90s, it became clear that computing would allow them to manage the stockpile of nuclear weapons with simulations rather than having to go and actually explode the bombs. When you have a mission of that order, and that complexity, people get very focused on developing computing systems to support your work. Up until then, the way people had been designing computers was just playing around, trying different things.

"ASCI kicked off," Sexton adds, "and has had a sequence of supercomputers developed ever since. There were a

BEOWULF CLUSTERS

You don't need a supercomputer to achieve high-performance computing. The Beowulf Cluster, from an original idea by Thomas Sterling and Donald Becker at NASA in 1994, is a group of normally, but not necessarily, identical PCs networked together and running software that shares processing between them.

Most run Linux, or BSD distributions tailored to the task, such as ClusterKnoppix, but there's nothing specifically that marks a cluster out as a Beowulf, that's just the name of the original grouping.

Since 2017, every system on the Top 500 list of supercomputers has used Beowulf methods to some degree, aided by the fact that such a cluster is almost infinitely expandable, limited only by network overheads. To this end, the simple Ethernet that joins up a Beowulf has been replaced by optical connections in the fastest supercomputers, with Nvidia's NVLink providing a bridge between its GPUs.

The idea is popular with Raspberry Pi owners, as the inexpensive boards can scale through a simple network switch and the Message Passing Interface software. Such a cluster can make a nice web server, or for learning Docker or Kubernetes, or as a fast file server for a home office setup.

A Raspberry Pi 4 cluster case by MakerFun, with four Pis installed.

© MAKERFUN, WIKIPEDIA

number of players in the early days: IBM was providing some of the computers, Cray was providing some of the computers, a couple of other names too, and what quickly happened is that there was an insatiable demand for computing power. And there was a limit on how much power you could deliver to a laboratory to run a computer. We're up to 40 or 50 megawatts today, the biggest ones in the world are our own national labs in the US."

This hunger for power has led to a new consideration in supercomputer design—efficiency. Born out of a five-year plan to build a massively parallel computer to address protein folding and other biomolecular phenomena, the project had a secondary aim of exploring new ideas in parallel computing architecture, the problem with supercomputers being that new ones are hard to simulate on existing hardware. In the early 2000s, there was a bit of a plateau in computer speeds. NEC's Earth Simulator had been at the top of the rankings from March 2002 until November 2004, its 35.86 teraflops pushing out ASCI White's 7.226 teraflops that had been top for a year previously.

"Blue Gene was designed to be power-efficient," says Sexton of a machine that forced its way to the top with 70.72 teraflops before losing the title to another IBM machine, Roadrunner at Los Alamos, in June 2008. "We were building systems with 100,000 CPU cores in the early 2000s, and that was unheard of at the time, to be able to get that many computer cores to work coherently together.

"And then towards the end of that time, what emerged was GPU acceleration. It turns out that GPUs are actually quite power-efficient, and a significant strain on the design of computers is your ability to manage power. A lot of systems design is about how to get more and more computing power into a system, but staying within a given power. The Blue Gene architecture used incredibly simple, lightweight, low power cores, but by the time we got to around 2014 or 2015, it became clear we would not be able to continue to improve performance with that technology."

MODERN DAY

Trading power consumption for speed, Blue Gene/L (originally 'Blue Light') contains two PowerPC 440 cores running at 700MHz with floating-point accelerators in each node, with 1,024 nodes in each 19in rack, up to a minimum of 64 racks (65,536 nodes). A lightweight Linux OS further pares back the overhead. Blue Gene/P further developed this, with its PowerPC 450 cores running at 850MHz and with twice the chip-to-chip bandwidth of the L model, but with four cores per node and 4,096 cores per rack.

Blue Gene/Q dispenses with PowerPC, using instead IBM's A2 open-source architecture. This means 18-core chips with four threads per core and a speed of 1.6GHz. Each rack contains 1,024 compute nodes, 16,384 user cores (16 are available, the 17th runs the OS, and the 18th is either a redundant spare or there to increase manufacturing yields) and 16 TB RAM.

Blue Gene is also notable for sprouting Deep Blue, the computer that beat Grandmaster Gary Kasparov at chess in 1996. With its roots reaching back to 1985, and earlier attempts to teach a computer to play chess, Deep Blue is more of an ASIC (Application Specific Integrated Circuit) as it uses specialized chips alongside IBM Power2 processors to brute-force solutions to chess problems rather than displaying modern artificial intelligence.

The Cray XC-40, also known as Hazel Hen, at the High Performance Computing Center of the University of Stuttgart. It began operation in 2015.

The CM-1 at the Computer Museum of America, with its plethora of red LEDs.

Above: **One node of the Fugaku supercomputer.**

Left: **Part of IBM's Summit supercomputer.**

"We are at the limit of what it is physically possible to program and manage, so then we did a switch to work with Nvidia and built the fastest computers in the US National Labs: Summit and Sierra. They have tightly coupled CPUs and GPUs, and are at 200 petaflops today."

Planned machines will produce more than an exaflop of computing power, comparable to that put out by Folding@home during the great push to discover vulnerabilities in the protein-coding of the SARS-COV2 virus. "We're at a disruptive time in computing," says Sexton. "We're running out of technology, and yet the demands of computing continue to grow. The ability for AI to do things, to get you more access to knowledge, it requires more and more compute. If you think of a self-driving car, something a lot of people talk about, getting a computer to drive a car is actually quite a lot, so you're seeing huge amounts of concrete everywhere.

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Blue Gene/P at the Argonne National Laboratory, in Lemont, Illinois.

"The history from 1995 to today and into the next few years has been driven primarily by the mission activities that have supported nuclear weapons," he continues, "and all the science that goes around understanding materials, understanding climate, understanding weather, understanding biological systems, so we're now at the point where you can actually do serious simulation. Every five years, we were seeing a tenfold increase in peak performance. We're now at an exaflop, so we've gone three orders of magnitude, in terms of performance, in 15 years. It's absolutely amazing that that's possible, but hard to see how it's going to continue.

"On the other hand, the computing that we do is changing drastically now. It's less and less about trying to focus on understanding basic physics and more and more about AI, and data analytics. It's been a very interesting ride, but I don't think the future of computing is going to be around nuclear weapons. I think we've reached the limits of traditional computing, but we have all these new capabilities coming too."

FUGAKU KING

This may explain how Fugaku, a system made of an ungodly number of ARM-based CPU cores and no GPUs, was able to overtake Summit in June 2020 to take the top spot on the big list of really fast computers. Competition between nations for the prestige of hosting the world's greatest supercomputer may still be a factor, but we may have to look elsewhere, such as distributed computing systems, to catch the really big numbers in future.

Or we could change the way we design our computers. A resurgence in analog computing, maybe? "We as humans, we don't really work as precise ones and zeros," says Sexton. "Our brain computes analog, and it does a pretty good job. When you look at a lot of the domain out there, do I need a computer of ones and zeroes to drive a car? Would it be better to go to an interesting, analog, future?

"An analog computer deals with a range of values," he continues. "It doesn't give you a precise binary value for something. And then there's a different way of calculating, and you do that by having different materials analyzing the different programs or occasional model. In-memory computing is another one. More and more challenging computing is moving away from the old Von Neumann model, where you have your data in memory and move it to a computer to compute. We're looking for ways around that because a significant amount of the power in the computer is going into moving data."

Whatever happens, as quantum computers approach from left-field or new materials other than silicon become more common in microchip manufacture, we may never leave the age of the supercomputer behind. They may just fade into the background of our society, giant machines that help when great scientific problems need solving and spend the rest of their time predicting the weather. But that's another story.

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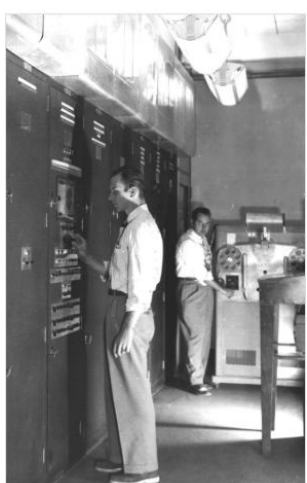
THE VON NEUMANN MODEL

The Von Neumann Model is a computer architecture, first proposed in 1945, that makes up the majority of computers in the world today. It is named after John von Neumann, a Hungarian child prodigy who came to the US in 1937 and ended up working on the Manhattan Project.

In 1945, he wrote a document called the First Draft of a Report on the EDVAC, in which he described a "high-speed automatic digital computing system". He divided it into six major parts: a central arithmetic part, a central control part, memory, input, output, and (slow) external memory.

The word 'bit' had not yet been coined, but Von Neumann detailed a system using 27 binary digits to represent numbers up to eight decimal places. On top of this, he added ways to distinguish numbers from one another, reaching 32.

The EDVAC was the successor to ENIAC, proposed in 1944 and delivered in 1949. Its importance comes in its ability to store programs in the same memory as the data to be processed, something that would influence the design of almost every computer after it. A computer with separate program and data memories is said to follow Harvard Architecture.



The EDVAC installed in the Ballistic Research Laboratory at Aberdeen Proving Ground, Maryland.

CENTERFOLD

...CE GEAR LAID BARE

1 ELGATO RING LIGHT

As anyone who's spent any time doing photography and videography knows, good lighting is key, and the Ring Light aims to give you just that. With a diffused set of OSRAM LEDs surrounding the ring, you can easily mount your camera to the middle, and light yourself perfectly every time.

2 ELGATO GREEN SCREEN

Elgato's collapsible green screen is a well-designed and solid piece of kit. Using this and a software suite, such as OBS Studio, means it's easy to remove your background from the shot entirely. This gives your stream a cleaner look and keeps your surroundings a little more private too.

Stream Perfect

STREAMING HAS BECOME entrenched in our community over the last decade or so. What started out as a niche hobby, a spin-off of YouTube "let's play" videos, has quickly blossomed into a beast of an enterprise with massive superstars and big paychecks. Live streaming covers everything from the latest AAA game playthroughs, eSports competitions, PC building, cooking, DIY, and more. Think of a hobby and there's probably a streamer out there doing it now.

Live streaming also offers something that was often lacking in YouTube videos—authenticity. Those "HI GUYS!" YouTubers who fine-tuned their on-camera personas for a short skit have difficulty maintaining a fake personality on a live stream without slipping up. What you're left with is a platform of enthusiasts, who love what they do with genuine passion and authenticity. That, in our opinion, is kick-ass.

Once upon a time, it was expensive to get into streaming, but with greater competition and the advancement of technology, we're seeing more quality products make their way down to affordable levels than ever before. And as our computational tech gets better, even an everyday gaming PC can take on the strains of pumping those extra frames out into the ether for your viewers.

To help you on your way to streaming stardom, we grabbed some top-notch kit from Elgato that we'd recommend for building the ultimate live streaming setup at home. **-ZAK STOREY**

3 ELGATO FACECAM

It's far easier to build a bond with your audience if they can see your face, so good video quality is essential. You could use a modern mirrorless DSLR, but Elgato's Facecam is a solid choice. With support for HDR and uncompressed 1080p 60fps video, this is an awesome cam.

4 ELGATO WAVE:3

Next up on the priority list is making sure your voice comes through crystal clear. And that means a decent microphone and a few other choice features. Here, we have the complete Wave:3 'Pro Audio Bundle' that includes an extension arm, a shock mount, and a pop-filter to eliminate any unwanted background sounds, crackles, and pops.

GET INTO UBUNTU

The latest version of Ubuntu has landed. **Nick Peers** discovers what's new and shows you how to install it.

UBUNTU 21.04—known to its mates as Hirsute Hippo—is here and demanding your immediate attention. If you're running Ubuntu 20.10, then you've probably already had the update reminder, while those running Ubuntu 20.04 LTS may be getting itchy feet and wondering whether now is the time to switch to the six-monthly release cycle, at least for the next year.

And what if you're thinking of switching to Ubuntu for the first time? Perhaps you're fed up with broken Windows updates and constant privacy creep as it tries to trick you into surrendering yet more of your personal data.

We'll kick off by looking at how you can test-drive the latest version of Ubuntu without committing to a full-blown install on your system. All you will need is a blank DVD or a spare USB stick, which then enables you to run a 'live install' that doesn't touch your existing system.

Want to try the full version, but aren't quite ready to commit? Discover how easy it is to install in VirtualBox. And when you're ready to give it a permanent home on your PC, we'll reveal how to install it alongside your existing operating system, making it possible to switch between the two as you see fit.

But what of Ubuntu 21.04 itself? We've explored the new and improved features to give you a full rundown of what to look for. The big talking point is a new default windowing system called Wayland. We'll explain what this is, what it means and whether, after one previous failed attempt, this is a change that will finally stick. We'll also reveal what else to look for in an update that, while not revolutionary, has lots of useful tweaks and improvements to make your computing life that bit easier.

And we ask the question: do you need to upgrade, particularly if you're currently on the LTS (long-term support) channel?

© MAGICTORCH

Install Ubuntu 21.04

Looking to switch to Linux from Windows? Discover how to take Ubuntu for a test drive, then install it alongside your existing operating system.

THE RELEASE OF ANY NEW VERSION of Ubuntu is bound to attract potential switchers from other operating systems. These days, installing most types of Linux in general, and Ubuntu in particular, is no harder than installing Windows, and in many ways, it's much easier.

Crucially, it's also free and, unlike Windows, there are several ways in which you can give Ubuntu a test drive without committing to a full-blown install. The Ubuntu installation media doubles up as a live disc, which loads a fully functioning version of Ubuntu without touching your hard drive, giving you the chance to try out its user interface and key programs in minutes.

If you want to take it further, we recommend running it in a virtual machine, enabling you to install and try out everything Ubuntu has to offer over an extended period. If you decide you'd like to run it permanently and natively on your PC, we'll take you through the process of setting Ubuntu up alongside your existing Windows installation, so you can easily switch between the two.

CREATE YOUR BOOT DISC

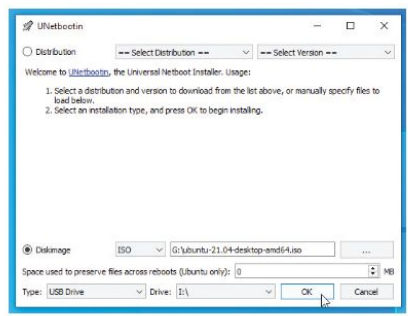
First, obtain your Ubuntu installation media. Visit https://ubuntu.com/download/desktop to download the desktop version. You have a choice of two versions: choose the newer (21.04) version if you want access to the latest features and are happy with upgrading Ubuntu every six months or so; the LTS version only updates once every two years and is supported for five years as opposed to nine months for non-LTS releases.

Save the ISO file to your hard drive. It's around 2.6GB in size, so may take a while to download (it's on the LXFDVD too) depending on your internet speed. Once saved to your hard drive, the ISO file can now be copied to install media or used directly with VirtualBox. If you're looking to create installation media, then the simplest option is to pop a blank DVD into your DVD writer, then right-click the ISO file and choose Burn disc image.

Bootable DVDs are simple to set up, but they're slow. If you have a spare USB flash drive (4GB or later) that you're happy to devote to Ubuntu, format it as FAT32. Next, download and run Unetbootin (https://unetbootin.github.io). Select Diskimage and click ... to select your ISO file. You'll see 'Space used to preserve files...' option, which basically creates 'persistence'. For a quick test of Ubuntu, leave this set to 0. Plug in your USB drive and select it from the Drive drop-down, then click OK.

BOOT FROM UBUNTU

It's time to give Ubuntu a test drive. Reboot your PC with the DVD in the drive or USB flash drive plugged in. If you're lucky, your PC will be set up to detect your boot drive and reveal a simple loading screen—you can skip to the next section.



Create your USB boot media with the help of Unetbootin, available for Windows, Mac and Linux.

If you boot straight back into Windows, restart your PC again and look for a message enabling you to press a key to either enter the BIOS/UEFI setup utility or select a boot device. Choose the latter, then select your bootable media from the list. If it appears twice, try the UEFI option first. If neither option works, then you'll need to boot to the UEFI setup utility and look for options to disable QuickBoot or FastBoot and Intel Smart Response Technology (SRT).

You may also need to disable Fast Startup in Windows itself. Navigate to Settings→System→Power & sleep and click 'Additional power settings'. Click 'Choose what the power buttons do' followed by 'Change settings that are currently unavailable' and untick 'Turn on fast start-up (recommended)'.

TESTING UBUNTU

If your boot media is detected, then you should see a boot menu appear with various choices—leave the default Ubuntu selected and hit Enter. This should now load Ubuntu to the point where you'll be given the option to either try or install Ubuntu. Click Try Ubuntu to find yourself at the Ubuntu desktop. You can now go exploring. It's mostly a point-and-click interface, just like the Windows you know and... [Don't say it—*Ed*].

The problem with live discs is that by default you lose all your changes once you shut down, so you're only going to get a small taste of how Ubuntu works. If you'd like to give it a more extended test drive, then check out the box (see overleaf) on running Ubuntu 21.04 as a virtual machine.

You should be able to road test all its new features, and it will even run the Wayland desktop server by default (more on that later).

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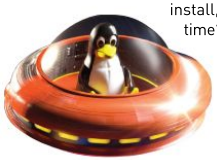


UBUNTU AND WINDOWS, LIVING TOGETHER

You've tested Ubuntu and realized the benefits of having a full-time install. So what's next? If you have a spare computer, you could wipe its drive and install Ubuntu directly on to that, following the same process you did when installing Ubuntu into a virtual machine, selecting 'Erase disk and install Ubuntu' when prompted.

However, what if you only have a single PC and want to run Ubuntu as an alternative to your current Windows install, swapping between them as required at boot time? The answer lies in configuring your PC as a dual-boot setup. For this to work, you can either install Ubuntu onto its own dedicated hard drive or, if you have sufficient space, partition your existing hard drive to make room for a dedicated Ubuntu partition.

There's no substitute for running Ubuntu off a fast internal drive—SSD definitely, or even an NVMe drive if your motherboard supports it. If Windows is currently installed on this drive, and you have enough free space, say 80GB or more, then partitioning it may be the best solution.

STEP THROUGH THE INSTALL PROCESS

When your drives are set up, boot from your Ubuntu live media and choose Install Ubuntu. The install wizard is self-explanatory, you'll be prompted to connect to your Wi-Fi network if you don't have an Ethernet connection. We recommend ticking both boxes to download updates and install third-party software when prompted.

The Installation type menu is the trickiest part of the process. If you're dual-booting with Windows, you may get lucky and see that your system has detected your existing installation and offered an 'Install Ubuntu alongside Windows 10'. If so, leave it selected and click Continue. If not, you'll need to look at manually partitioning it. Our step-by-step guide (opposite) reveals how to do this using the Ubuntu live media.

Once past this point, the rest of the installation process should be simple. If all has gone well when you reboot your PC for the first time after installation, you'll see a GRUB menu that makes it possible for you to choose whether to load Ubuntu or Windows. Select Ubuntu and you'll be whisked to the login screen, ready to start using the latest version of the Linux distro.

TEST-DRIVE UBUNTU IN VIRTUALBOX

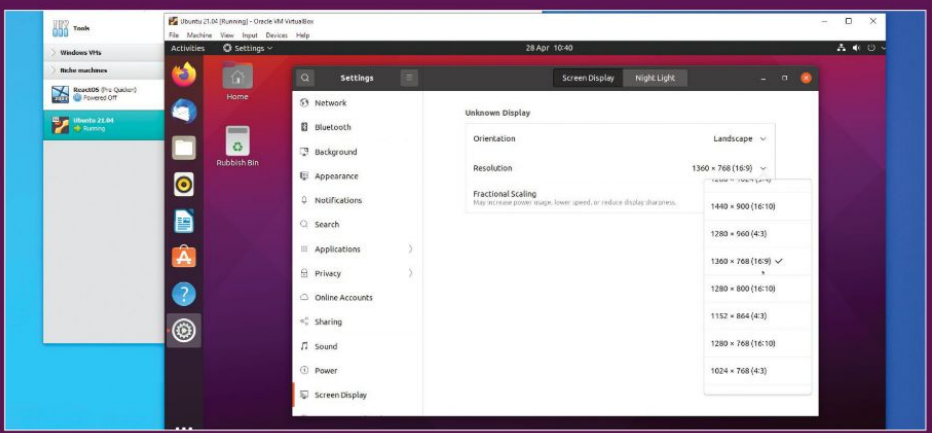
If you'd like to give Ubuntu a thorough test drive without committing an entire PC to it, the next step is to run it inside a virtual machine (VM). The best tool for the job is VirtualBox (www.virtualbox.org). You'll also need a copy of the Ubuntu 21.04 install media in ISO format from www.ubuntu.com/download.

In VirtualBox, choose Machine→New. Type Ubuntu 21.04 into the Name field and you'll see it automatically assigns its type (Linux) and version (Ubuntu 64-bit). Check the default Machine Folder and change the drive if necessary, to one that has at least 32GB spare. Click Next and allocate it a minimum of 2,048MB (2GB) RAM, though preferably more. Leave 'Create a virtual hard disk now' and click Create followed by Next twice, then set the size to 32GB and click Create.

Your new VM will be created. Next, click Settings to tweak its hardware settings. If your PC is powerful enough, select the System→ Processor tab to allocate it between two and four CPUs. Select Display and tick Enable 3D Acceleration and allocate the maximum (128MB) amount of video memory you can. Finally, under Storage select the Empty DVD drive under Controller: IDE and click the disc button on the right to select your Ubuntu 21.04 install ISO file.

Once done, click OK followed by Start to launch your VM, then follow the steps to install Ubuntu. It's a simple process in a VM: just leave 'Erase disk and install Ubuntu' selected under Installation type and click Install Now when prompted. At the end, it will automatically 'eject' the install disc, so press Enter to reboot.

When you boot into Ubuntu itself, the screen will initially be cramped. Skip through the first-run wizard, then open Settings→Screen Display to choose a more comfortable view, eg. 1,360x768.



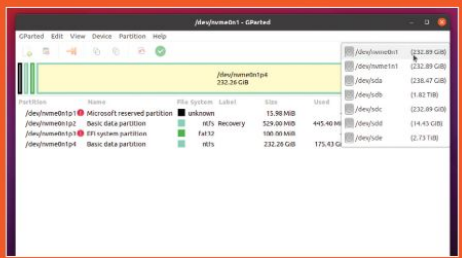
Ubuntu 21.04 installs like a dream in VirtualBox, enabling you to give it an extended test drive.

© MAGICTORCH, UBUNTU

PARTITION YOUR HARD DRIVE FOR A DUAL-BOOT SETUP

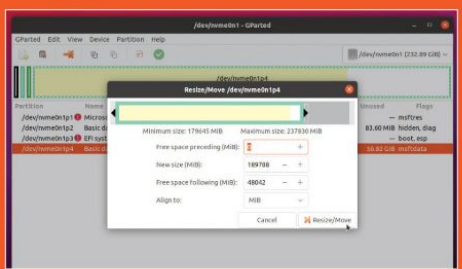
1. USE UBUNTU LIVE MEDIA

The simplest way to partition your drive is using the Ubuntu live media. After clicking Try Ubuntu, click the icon at the top of the Launcher on the left to open the Dash—this is the tool used to search Ubuntu. You should see GParted in the list (type `gparted` to bring it up if not), click it to launch the tool.



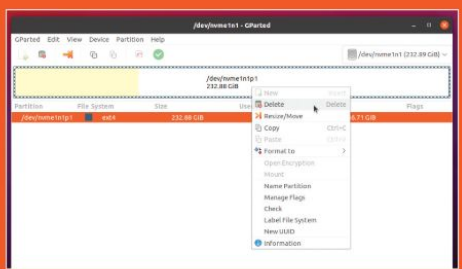
2. SELECT TARGET DRIVE

GParted will open with the current boot drive (typically dev/sda, or dev/nvme0n1 in the case of NVMe drives) selected in the top right corner. This should be the drive Windows is installed on if you wish to share it with Ubuntu. Use its size and the partition list beneath to verify it is the correct one.



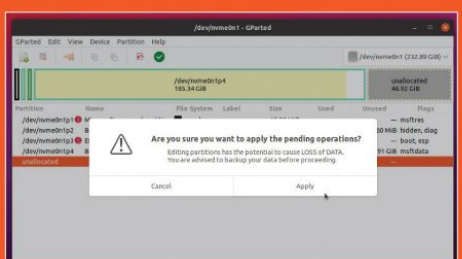
3. FREE UP SPACE FOR UBUNTU

Examine the partition layout. Right-click the largest partition on the right to resize it if it has enough free space—74GB is an ideal minimum. Click and drag the right-hand slider to the left to free up the space, leaving at least 10GB free space for the existing partition. Click the Resize/Move button.



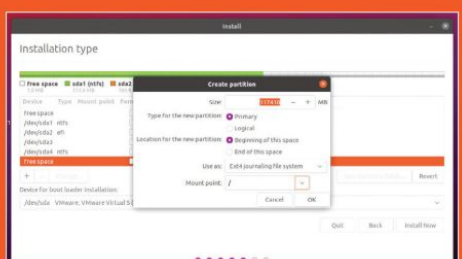
4. PREPARE DEDICATED DRIVE

To install Ubuntu to its own drive, click the /dev/xxxx list to view other drives. If it's a new drive, it will show up 'unallocated'; otherwise, existing partitions will be visible. Confirm there's nothing worth keeping on the drive, then right-click any visible partitions and click Delete.



5. APPLY CHANGES AND INSTALL UBUNTU

Click the green tick. Read the warning—if in any doubt, click Cancel and review your changes again. If you're happy, click Apply and wait for the partitioning to complete. When done, click Close, then exit GParted and double-click Install Ubuntu 21.04, following the wizard to the 'Installation type' screen.



6. SET UP A LINUX PARTITION

If 'Install Ubuntu alongside Windows Boot Manager' is selected, click 'Install Now'; if not, choose 'Something else'. Locate your drive's free space and click +. Set the Mount point to /, then click OK. Verify the drive Windows is on is selected for 'Device for boot loader installation', and click 'Install Now'.

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Wayland strikes back

Ubuntu 21.04 attempts to reintroduce Wayland as the default desktop server. Will it succeed second time around?

THE HEADLINE NEW FEATURE in Ubuntu 21.04 is that Wayland has been restored as the default windowing system. After one previous failed attempt to replace the aging, if trusty, Xorg server back in Ubuntu 17.10, the folk at Canonical hope that second time's a charm and have given themselves a year to make this attempt stick before the next LTS is released.

So, what exactly does a display server do? It provides your PC with the means to run graphical environments powered by desktops like GNOME, enabling you to point and click rather than spend all your life at the command line. Think of it as a connecting layer that sits between the kernel and your chosen desktop environment.

For decades, Linux has relied on the X Windows display server, which since 2004 has existed in open-source form via the Xorg fork. It has been constantly evolving since the 1990s but is finally creaking under the twin burdens of increasingly unwieldy code and the demands of new graphic technologies.

In 2008, Wayland was born as a replacement to X. It aims to provide a simpler, slimmer, and more secure alternative, so what's not to like? It simplifies things by unifying the various elements involved in rendering graphical displays, including compositor, display server, and window manager, in a single protocol.

It's slimmer because it drops the client-server architecture of X, which enables you to connect to a server from a client machine via a desktop environment as opposed to simple SSH. Wayland's reasoning is that most users don't need this overhead—and if you do, it's not a problem, as the box (left) on XWayland reveals.

It's also designed to be future-proof. X struggles with supporting high-resolution displays and multi-GPU setups, two things (among others) that Wayland can actually handle. And finally, Wayland is more secure. Xorg enables applications to read output from and send input to any other application, which can be easily exploited by keyloggers and other forms of malware. Wayland forbids this behavior.

ACCESSING WAYLAND

With Ubuntu 21.04's release, Wayland is once again the default desktop server. You shouldn't notice any difference—GNOME is still the desktop, and the only difference is that it's running on top of Wayland rather than X. You can verify this by navigating to the About page under Settings and examining what's listed next to Windowing System.

If you see Xorg listed as the windowing system, we'd bet on the fact your PC sports Nvidia graphics running off a proprietary Nvidia driver rather than the open-source, less powerful Nouveau driver.

Nvidia has long dithered on improving its support for Wayland, but it seems the fact its drivers are blocked from using Wayland—largely because they don't support hardware acceleration of X programs under XWayland—has finally stung the graphics card manufacturer into action, having sat on the issue since it was first reported back in April 2019.

To cut a long story short, the next major driver release (the v470 series) will contain two patches that finally support hardware-accelerated OpenGL rendering and Vulkan rendering with XWayland. However, this suggests that it won't be until Ubuntu 21.10 when full Nvidia support for Wayland will be implemented.

In the meantime, if you want to switch to Wayland now, you have two choices. You can open Software & Updates settings and switch back to Nouveau via the Additional Drivers tab. Alternatively, you can remove the blocks put in place to prevent Wayland from running

XWAYLAND MARKS THE SPOT

Backward compatibility is always a good thing when migrating away from a fundamental part of your operating system, which is where XWayland comes in.

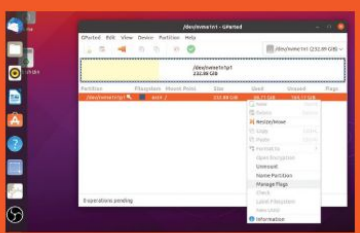
Legacy programs will only support the X windowing system, and XWayland provides Wayland with an X Server to facilitate them. The good news is that XWayland is installed alongside Wayland by default, so it's just there, ready to provide you with X Server support when you need it, which covers most games.

Better still, you only need know that XWayland exists, and there's no configuration involved. You needn't worry about performance, either. Benchmarks indicate that performance in Wayland is virtually identical (except with Nvidia drivers, hence the block).

To find out if an open window is using Wayland or XWayland, launch xeyes from the Terminal. Roll your mouse over an open window—the eyes will only move if that window is using XWayland.

XWayland isn't a perfect workaround. You may encounter specific issues with certain programs, such as those trying to do things that fall foul of Wayland's security settings.

There may be some outstanding performance issues too, for example, where input events are tied to your monitor's refresh rate. This can cause problems with mouse movement and clicks.



Open xeyes via the Terminal and roll the mouse over a window. If the eyes move, then you know that window is running XWayland.

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under Nvidia drivers by tweaking several system files. Our step-by-step guide (below) reveals how to achieve this. Note, however, that you're likely to encounter performance and compatibility issues—we noticed stuttering in YouTube videos in Firefox, for example—and so we'd suggest sticking with X or switching to the Nouveau driver.

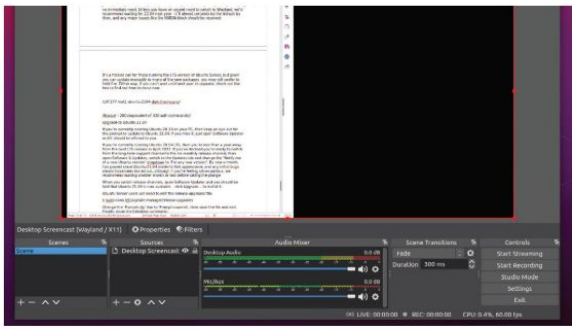
THE TROUBLE WITH WAYLAND

While things have undoubtedly improved (yay, screengrabs!–*Ed*) since Ubuntu's last abandoned attempt to make the switch to Wayland, there are still some outstanding issues to consider. If you like Ubuntu but don't like GNOME, then be wary of switching to another desktop without first checking whether it's Wayland-compatible. KDE Plasma 5 and Enlightenment e20 are compatible, for example, but the popular Cinnamon desktop still only works with X.

While XWayland enables programs that are built around X to continue working, on the whole, Wayland's security architecture does create problems elsewhere. For example, screen sharing and remote desktop applications that rely on X won't work in XWayland without specific fixes. Developers should look into technologies such as PipeWire and xdg-desktop-portal-wlr, that can resolve such issues.

End users shouldn't worry too much: solutions to key problems have already been integrated into Ubuntu 21.04. For example, GNOME's built-in Remote Desktop tool supports the popular VNC remote desktop protocol out of the box. To make your PC accessible to others, simply navigate to Settings→Sharing, flick the big switch on and then click Screen Sharing to set it up, all without installing any other programs.

Looking for a live-streaming or screen-recording tool that works in Wayland? OBS Studio 27.0 sees the efforts of one diligent developer to integrate native Wayland support (you can read about his "long road" at http://bit.ly/lxf277obs). If version 27 isn't available to install via snap by the time you read this, try the current flatpak release instead, which incorporates the plugin required to stream or record Wayland windows.



OBS Studio supports Wayland natively. The simplest way to get it is to install through Flatpak.

FIXES AHOY

Elsewhere, developers are keen to incorporate native Wayland support into their tools. In many cases, the fixes are upstream via the APIs and other elements used to build their applications, so they may be forced to wait on these. For example, the versions of Firefox and LibreOffice that ship with Ubuntu 21.04 both natively support Wayland, but Thunderbird still requires XWayland. Blender 2.90 recently launched with initial Wayland support (you need to build it with the `WITH_GHOST_WAYLAND` option), while Wine's developers are working to implement native Wayland support, with several unreleased patches demonstrating future Wayland functionality, such as copy and paste, drag and drop, and the ability to change the display mode.

Canonical has given itself a year to iron out any issues with Wayland before the next LTS release. Our bet is that come Ubuntu 22.04 LTS's release next year, Wayland will be the default windowing system on all PCs, including those running Nvidia graphics.

If this sounds like an unnecessary faff, or your favorite programs refuse to work with Wayland, then log out of your current session, click your username, and then click the Settings button to switch to GNOME with Xorg.

GET WAYLAND WORKING ON NVIDIA

1. CONFIGURE NVIDIA-GRAPHICS-DRIVERS.CONF

Type `sudo nano /etc/modprobe.d/nvidia-graphics-drivers.conf` and hit Enter. A blank file or existing config file may open. Simply add the following line, save and then exit:

`options nvidia_drm modeset=1`

2. CHECK /ETC/GDM3/CUSTOM.CONF

Now type `sudo nano /etc/gdm3/custom.conf` and hit Enter. Verify the line `WaylandEnable=False` has been commented out like so:

`#WaylandEnable=False`

Save and exit again.

3. COMMENT OUT RULES

Type `sudo nano /usr/lib/udev/rules.d/61-gdm.rules` and hit Enter. Make sure all lines are commented out using # as shown above. Save and exit, then reboot When you log in, you should see a settings cogwheel on the main screen. Verify that it is set to Gnome to boot into Wayland.

What's new in 21.04?

It may not be packed full of eye-catching new features, but Ubuntu 21.04 features plenty of improvements.

WAYLAND MAY BE DOMINATING the headlines, but it's by no means the only new feature that's arrived in Ubuntu 21.04. Several other features are linked to Wayland, of course—the PipeWire project for one, with its aim of "greatly improving handling of audio and video under Linux". It's basically a replacement for pulseaudio and JACK, designed to work with containerized Flatpak applications, but also tying in neatly with Wayland's tighter security requirements.

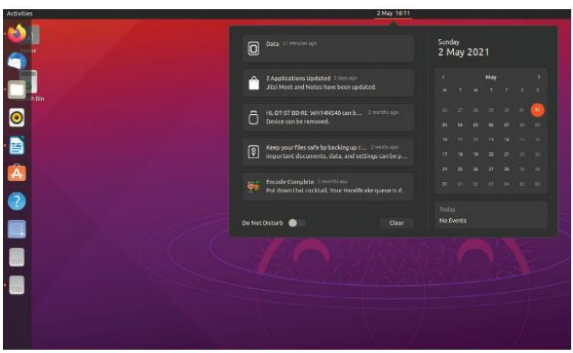
In practical terms, its primary function is to restore the ability to both screen-share and record your desktop with compatible applications such as OBS Studio and Discord. It will also improve audio support in sandboxed applications, such as those installed through Flatpak.

One interesting choice made in Ubuntu 21.04 is the one to stick with GNOME 3.38 (or more precisely, 3.38.5). This means that the desktop remains a familiar one, despite the recent release of GNOME 40. As a result, no radical desktop changes, such as the controversial switch to dynamic horizontal workspaces, have been implemented this time, although selected GNOME applications, including System Monitor, have been updated to their GNOME 40 versions behind the scenes.

There are some subtle changes to the desktop's appearance, such as a shift to using the Dark Theme by default for UI elements on the menu bar, including status menus and the Calendar tool. In addition, look out for some small, but pleasing, updates to the Nautilus File Manager, including icon redesigns that incorporate rounded corners.

DESKTOP IMPROVEMENTS

One major change that should make life a lot simpler is the incorporation of a new desktop extension that finally handles drag-and-drop interactions between desktop and applications (such as via the file manager) properly.



One minor tweak is that all menu bar items, including the Calendar, now switch to the Dark Theme by default.

Take a trip to Settings→Power where you should find that you can now configure power profiles from the friendly GUI—assuming your configuration has proper kernel support. Simply switch between 'balanced power' and 'power saver' as required. This feature is clearly aimed at laptop users, with the only downside being that your settings won't survive a reboot.

The default programs Thunderbird, Firefox, and LibreOffice have also been updated to the latest versions at the time of release. LibreOffice is now up to 7.1.2.

SECURITY IMPROVEMENTS

There are several welcome security updates in Ubuntu 21.04 worthy of highlighting. First, users' Home folders have finally been made private. This means that users can no longer easily browse the contents of other users' home folders unless their permissions have been tweaked accordingly.

If you're planning on installing Ubuntu 21.04 from scratch on an encrypted partition, you'll be glad to know that a fail-safe now exists in the form of an optional recovery key file, which you can use to recover your system if anything untoward happens. Look out for the option appearing during the install process.

The built-in firewall now has nftables as its default backend. You can still use the more user-friendly ufw frontend to manage the firewall from the command line and should notice no difference in functionality. The main advantages of using nftables over iptables are that it's easier to use when addressed directly, has no pre-defined tables or chains making it fully configurable, and should be easier to update with new protocols.

Finally, UEFI Secure Boot has been improved and now supports SBAT-capable shim, grub2, and fwupd, which is a necessary consequence of the recent BootHole security vulnerabilities that were disclosed. The desktop also gains support for smartcard authentication, which can be used in place of passwords for logging on to your system.

The kernel has also been upgraded to 5.11 (Ubuntu 20.10 ships with kernel 5.8) and, in addition to further security fixes, you'll also benefit from the latest hardware support and other performance improvements. Notable examples include reduced memory swapping thanks to better anonymous memory management, fsync() performance improvements for both ext4 and btrfs filesystems, and support for the latest graphics technologies, such as Intel Rocketlake and AMD Vangogh.

DEVELOPER AND SERVER CHANGES

In its blog announcing Ubuntu 21.04, Canonical focused largely on enterprise users and developers, stressing new Microsoft-friendly integrations such as native Microsoft Active Directory integration and support

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for Microsoft's SQL Server, which have also been backported to Ubuntu 20.04.2 LTS.

Elsewhere, you'll find key toolchains have been updated too, including Python (now version 3.9), Perl, Ruby, and PHP. OpenJDK 16 sits alongside OpenJDK 11 for Java support.

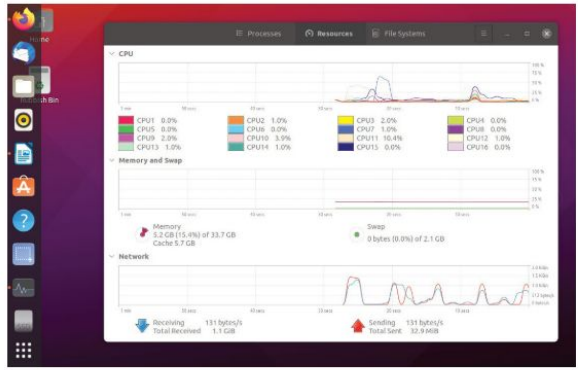
Canonical also appears keen to push LTS server users into upgrading to this new release with lots of major component updates. Rails 6 is a particular highlight, with support for rich text material and a controller-like mailbox along with parallel and action cable testing.

There's also Openvpn 2.51, with the promise of faster connection setup and improved TLS 1.3, while Needrestart for Servers now comes pre-installed to provide additional help during the update process. It identifies which daemons need to be restarted after library updates and upgrades.

There are more than a dozen other package updates, including QEMU (5.2), Libvirt (7.0), DPDK (20.11.1), Containerd (1.4.4), and Docker.io (20.10.2). Check the release notes at https://discourse.ubuntu.com/t/hirsute-hippo-release-notes/19221 for full details.

IS IT TIME TO UPGRADE?

It's true to say Ubuntu 21.04 is likely to be remembered as the update that finally made Wayland stick as the new default desktop server. But while there isn't anything major to get excited about, there are enough minor improvements to easily justify moving on up from Ubuntu 20.10 sooner rather than later. Being able to drag and drop files between desktop and applications is potentially worth the update on its own.



Although GNOME itself hasn't been updated to version 40, many underlying GNOME tools have.

It's a harder sell if you're currently running Ubuntu 20.04 LTS, however. Given the new kernel (5.11) will be shipping in the next point release (20.04.3), there's no immediate rush to upgrade. Unless you have an urgent need to switch to Wayland, we'd recommend waiting for 22.04 next year—the windowing system will almost certainly be the default by then, and any major issues such as the Nvidia block should be resolved.

For those running the LTS version of Ubuntu Server, it's currently a trickier call, but given that you can update manually to many of the new packages, you may still prefer to hold fire. Either way, if you can't wait until next year to upgrade, check out the box (below) to find out how to do so now.

THESE EFI UPGRADES

If you're running Ubuntu 20.10 on your PC, then keep an eye out for the prompt to update to Ubuntu 21.04. If you miss it, just open Software Updater and it should be offered to you.

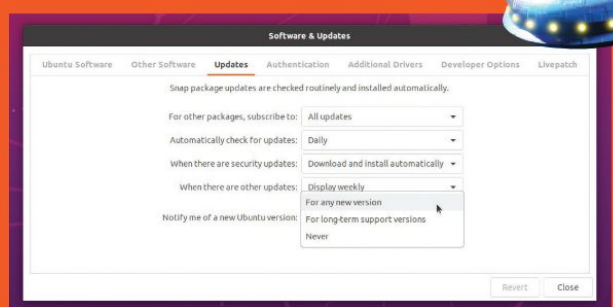
At the time of writing, the upgrade option was being held back because of a potential issue that prevents PCs running older EFIs from booting. This problem should be resolved by the time you read this, but if not, open Terminal and then issue the following command:

```
$ dmesg|grep "EFI v"
```

So long as the version number is greater than 1.10 you shouldn't be affected by the bug. If you're impatient to upgrade, force the upgrade with the following command:

```
$ sudo do-release-upgrade -d
```

If you're running Ubuntu 20.04 LTS on the desktop, then you're less than a year away from the next LTS release in April 2022. If you've decided you're ready to switch from the long-term support channel to the six-monthly release channel, then open Software & Updates, switch to the Updates tab, and change the 'Notify me of a new Ubuntu version' drop-down to 'For any new version'.



Switch release channels if you're ready to abandon LTS support for Ubuntu 21.04.

By now, a few months have passed since Ubuntu 21.04 made its first appearance, and any initial bugs should have been ironed out, although if you're feeling ultra-cautious, we recommend waiting another month or two before taking the plunge.

After you switch release channels, open Software Updater and you should see Ubuntu 21.04 is now available. Click Upgrade... to install it. Users running Ubuntu Server on their system will need to edit the release-upgrades file:

```
$ sudo nano /etc/update-manager/release-upgrades
```

Change the `Prompt=lts` line to `Prompt=normal`, then save the file and exit. Finally, issue this command:

```
$ sudo do-release-upgrade
```

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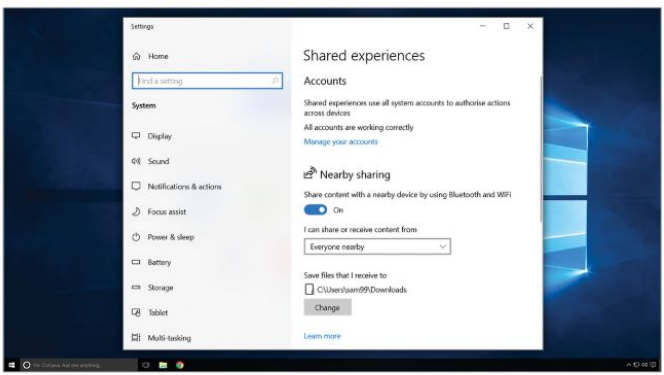
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



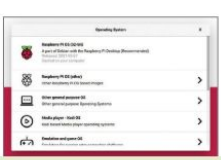
NEARBY SHARING

If you have multiple Windows devices or want to share files with another Windows device, then this tip may help you out—it's pretty much Microsoft's alternative to Apple's AirDrop. Go to the shared experiences tab in Windows settings and turn on nearby sharing. Now, when you hit the share button on items such as photos or documents, you should be able to see any computers nearby with the same setting applied. Then you should be able to send the files over to them hassle-free.

MAKE – USE – CREATE

64 Make minimal vector images in Illustrator

66 Back to 1984, with France's Thomson MO5



68 Build a Pi-Hole DNS server with adblocker for $10

SAM LEWIS
STAFF WRITER

SETUP IMPROVEMENTS

I'm lucky when it comes to tech and peripherals. The nature of writing product reviews and testing the kit for *Maximum PC* means that I often have a lot of cool gear I can use in my setup at my disposal. I can safely say that my desk is looking as sweet as it ever has. For the recent feature on streaming, I managed to get my hands on tech from Elgato, including its Wave:3 mic, Facecam, Ring Light, Green Screen, Stream Deck Mobile app, plus a Corsair HS80 headset. That's a nice setup if you ask me.

I'm not a vlogger or live streamer, so this gear will be used for the occasional bit of gaming, but mainly for the magazine's Google Meet calls. Unfortunately, for the rest of the team, they will now see and hear me in even better quality, which I'm sure they will love. I may even use the green screen to add a bit more of a wow factor to the calls, who knows?

I have loved using these items and it goes to show that having good quality peripherals can really enhance your productivity and enjoyment when using PCs. We all know the issues that come from poor-quality video and audio devices and how frustrating they can be, so it feels good to know that I am not causing these problems for anyone else on the team. Well, hopefully anyway.

↘ submit your How To project idea to: editor@maximumpc.com

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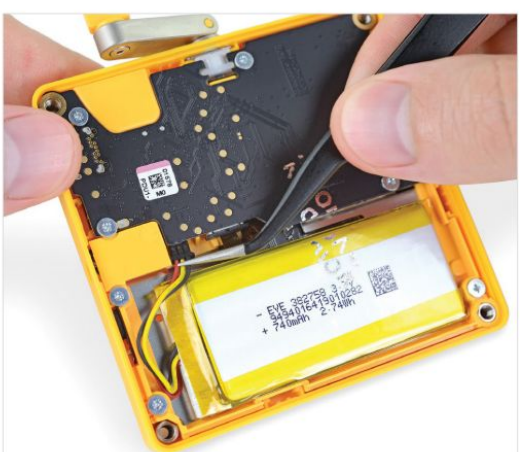
IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Playdate

Make sure you don't poke anything flammable with your tweezers. The battery itself is mildly glued down, so be persuasive but don't make it angry.



About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Panic says it made this quirky, definitely-not-a-Game-Boy device "just for fun," and we sure had fun tearing it down.

Inside the cavity of the mechanical crank handle is some secret intel, model number PDU1-Y

BACKGROUND

Panic, the company behind this quirky not-a-Game-Boy, says it made this device "just for fun," and it shows. From the 1-bit screen to its distinctive crank, the Playdate radiates novelty. We just hope it's as much fun to tear down as it is to play.

Full disclosure: Our unit came from Panic, who sent a Playdate for free. Unfortunately, it didn't come with any games, so a teardown was all it was good for. Little did they know, that's our favorite game. (Okay, they probably did know that).

MAJOR TECH SPECS

- Extremely high resolution (400×240) display—2.7-inch at 173 ppi
- 180MHz ARM Cortex-M7F CPU
- 16MB of onboard memory
- 4GB flash storage
- 2.4GHz Wi-Fi (b/g/n), Bluetooth 4.2, USB-C, headphone jack
- Mechanical crank, because why not?

KEY FINDINGS

- We grab our big flathead driver for this diminutive console and twist away some screws. A few plastic clips stand guard, but a first look inside reveals an easily accessible battery. Hold on, there's a warranty sticker guarding it. We carry on, carefully.
- Battery unpluggability: 8.5/10, mostly easy. Make sure you don't poke anything flammable with your tweezers. The battery is mildly glued down. It clocks in at 2.74 Wh (740 mAh @ 3.7V).
- We separate pretty much everything from pretty much everything else. Both the display and crank stay ensconced in the forward housing, but everything else just flips out, provided you're deft with a spudger. We get an early look at how the crank works. No gears, just a simple Hall-effect sensor and a thing, enshrouded in white plastic. Is it important? We'll see.
- But first, let's see what powers this pocketable piece of gaming goodness. The hidden side of the board contains seven key components, including 4GB of NAND flash memory and a whopping 128Mb of low-power SRAM. On the other side, there are six more chips surrounding the CPU.
- Time to pull the pin on this crank. There's a cylindrical magnet embedded in the shaft. As it cranks, the rotating magnetic field hits the Hall-effect sensor, which activates something in your game. One thing this crank won't do? Drift. There's no wiper, spring, or sensor surface to wear out. The design is simplicity itself. On the front, the tiny mono speaker is adhered in place.
- Here's where we come unstuck. The display is firmly glued to the enclosure, so to replace it, you'll probably need a new plastic face. Meanwhile, the buttons and other various I/O live on the flexible printed circuit, which is glued to the midframe. One bright spot, though, is the modular headphone jack.
- Does it go back together and still work? Indeed it does. Our repairability scoring model isn't calibrated for the Playdate. It exists in a category all of its own, and we dug in mostly for fun. But getting inside and getting some parts out isn't too painful.
- Repairability Score: 6 out of 10 (10 is easiest to repair). A big flathead screwdriver and an opening pick will get you inside. You can twirl away all the internal (Pozidriv) screws with a basic Phillips driver. The battery is accessible and only lightly adhered. The headphone jack is modular, and the crank design is simple and serviceable. You can swap the display, but only if you replace the front case. All of the controls are aggregated onto a single FPC—easy to swap, but wasteful if one thing breaks. The USB-C port is soldered to the mainboard.

Minimal vector portraits

YOU'LL NEED THIS

ADOBE ILLUSTRATOR CC 2020
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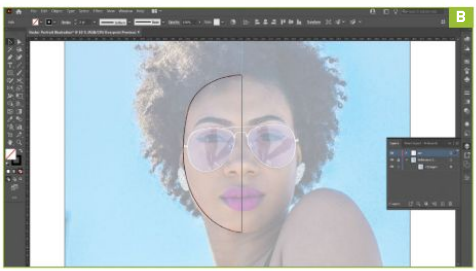
YOUR STYLE AND THEMES are a huge part of your work and can eventually become your design language. However, you may not want to limit yourself to one specific style and, besides, it's fun to find a new look and theme and play around with it. Illustrator is a great platform to design new ideas and to practice working on different styles. One of the most popular art styles you can create in Illustrator is flat vector artwork, which is something we touched on in our previous tutorials. This time, we focus on turning portrait pictures into flat vector artwork.

There are plenty of ways to use this technique. You can create images for yourself, such as a quirky profile picture for your design work or web page, or you could do it in a business way and create Illustrator images for customers. It could also be used as a gift idea and is endlessly customizable, it's a great way to spruce up a picture. Using the techniques in this tutorial, you can put this to the test and try it with other images, including landscape shots. –SAM LEWIS



1 GETTING STARTED

As always, we need to be organized throughout a project. This means keeping everything neat and tidy, ensuring that all the separate layers and items are where they need to be and are named appropriately.

›› Open up Illustrator and click 'create new'. For this project, we have decided to go with an RGB color space, but this is up to you—remember, though, use RGB for digital, and CMYK for print. Using the presets along the top, we select the poster workspace under the Art & Illustration tab. We also change the raster effects from 72dpi to 300dpi.

›› Once this is done, we can really start to get into this project. The first thing we need is a reference image. For this tutorial, it helps if the image is straight on, especially as we're just practicing our techniques at first. Further down the line, we'll be able to experiment with different angles and subjects.

›› We head to one of our favorite license-free image sites, Unsplash (https://unsplash.com) to browse for a suitable image. Once we have selected an image, we place it into our Illustrator document, crop it to size, and turn the opacity down [**Image A**]. Then we rename this layer as 'reference' and create a new layer called 'art', this is what we will be drawing on.

2 FACE TO FACE

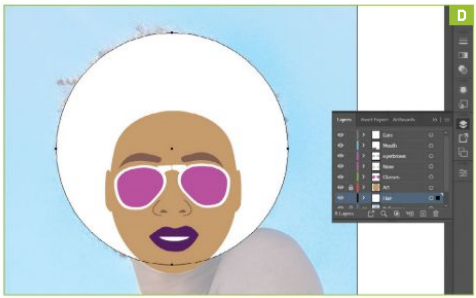
The first area of the image we will be focusing on is the face. We will be creating this symmetrically by tracing over one side first then reflecting it to create the full face.

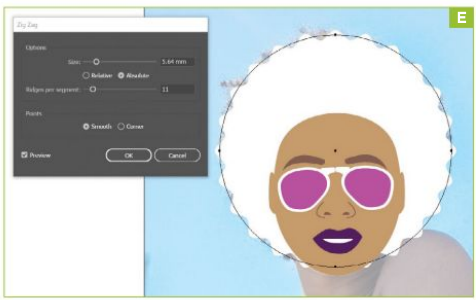
›› To find the centerline of the face, we need to bring a rule into the middle. Pressing 'CTRL' + 'R' will give a ruler border to the artboard. Then, simply click and drag from the side to bring a guide line out.

›› Once we have established the center, we need to use the pen tool. This is found in the left side tool panel, or with the shortcut 'P'. Then what you need to do is draw an outline of the face as seen above [**Image B**].

›› The next tool we need to use is the reflect tool 'O'. We click on the center guideline that was created earlier to set the reflection point. Next, we click on the shape created, and hold 'SHIFT + ALT' whilst, at the same time, dragging the reflected copy of the shape. Then, make sure both sides of the shape are selected and open up the properties tab. In this tab, under the pathfinder options, click the 'unite' button to create one shape, then choose a skin color with another stroke.

© PATRICIO/UPSPLASH.COM, ADOBE





3 ADDING THE FEATURES

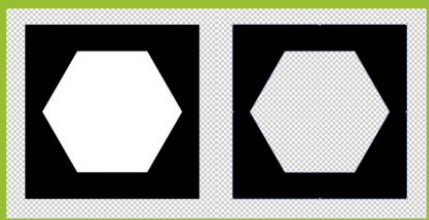
Now that the face is ready, the next thing to do is to start adding the features using the same technique. The curvature tool is handy for creating the smooth lines that we will need on the glasses.

›› In the same way as for the face, we create half the image again and use the reflect tool to keep everything symmetrical. It helps to create new layers for each feature so that you can always see the reference image. Remember, the tracing doesn't have to be exact, just as long as it is recognizable as the original image. This is a minimal vector version, after all.

›› We take the main shape of features and smooth them out to get the minimal look we were looking for. As we keep adding the individual shapes, the image starts to piece itself together. Once we've done everything, we check that we're happy with the face, though you can always go back and alter the shapes. After adding all the features [**Image C**], this is what we have for the face so far.

›› Using the same technique, we decide to add the outline of a pair of ears to the face shape, even though in the original image, it was hard to see them.

CUTTING OUT OBJECTS IN ILLUSTRATOR



Creating minimal vector imagery may seem pretty simple in theory, but it's easy to stumble across a few problems when creating your own images. One common issue is when you need to add detail into shapes, which often involves cutting shapes out of objects to create holes.

Again, it sounds simple, but can get quite confusing—unfortunately, you can't just use the eraser tool. After this mini-tutorial, hopefully this step will be made clear.

In the first image (above, left), the shape in the center is white but after a little transformation and cutting out, it is transparent (above, right).

One way of taking the front shape and cutting it through the back shape is by using the pathfinder. To do this, first highlight both shapes, then go to the pathfinder tab. In the shape modes section, go to the second icon called 'minus front'. When you highlight over the icon it should say this. Click on it and it should cut out the polygon shape from the square, as seen in our example.

Another way is to use the shape builder tool. Select both objects, hold the 'alt' key and select the object you want to cut through. Using these two tips should help massively to cut holes in your designs.

4 HAIR-RAISING ARTWORK

Adding the hair will bring the whole image together before we add a few finishing touches, including the background. The hair in the image is pretty large, so with the ellipse tool, we draw a large circle behind the face that covers the hair [**Image D**].

›› To create the frizzy texture, we use the zig-zag effect in the distort and transform tab. In this effect, we chose the smooth option for the point setting instead of the corner, which looks more like spiky hair. We also change the ridges per segment to get the desired look and play around with the size too. [**Image E**]

›› Once happy with the shape, we change the color to the pop-punk look we're aiming for in this minimal vector portrait and add a fringe using the same method.

5 BACKGROUND INFORMATION

There are a few things you can do to finish this image off. You could draw the rest of the body, create a minimal background, or leave it as it is. We opt for the latter and add a single color in the background [**Image F**]—in the original, this was all blue sky. Hopefully, after trying out this tutorial, you can use it to your advantage and create other artwork using this method. Think outside the box and apply it to different types of images.

Machine of the Month: Thomson MO5 (1984)

YOU'LL NEED THIS

DCMOTO
http://dcmoto.free.fr
Minimum Pentium II 300 MHz and Windows 98.

THIS MONTH, WE HEAD to France to explore a much-overlooked machine that can provide new experiences for hungry retro gamers. The Thomson MO5 is often referred to as "France's BBC Micro", and was the machine upon which many French schoolkids experienced their first taste of computing.

The MO5 uses unique hardware combinations with innovations well worth exploring, so let us take you on a brief tour of MO5 history, before showing you how to emulate this quirky machine. –JOHN KNIGHT

1 BACKGROUND

Thomson is a French sister company to General Electric, which began experimenting with computing in the 1970s. In the 1980s, Thomson started producing French microcomputers to capitalize on high import taxes, beginning with the TO7 (1982) and TO7/70 (1984).

›› These were primarily business machines designed to take on the Apple II and Commodore 64. However, developments in Britain changed their priorities.

›› Sinclair's cut-price ZX Spectrum was mopping up the UK budget market, and schools there had adopted the BBC Micro en-masse. Thomson wanted to monopolize both of these markets in France and attempted to do so with the MO5.

2 LAUNCH

Released in June 1984, the MO5 was a cut-down version of the TO7/70 that packed 32KB of RAM, a Motorola 6809E CPU, and Microsoft BASIC (called MO5 BASIC) for 2390 Francs, around US$400 at the time.

›› The MO5 has some peculiar hardware. Firstly, it used a Motorola 6809E CPU. The 6809 series had certain 16-bit capabilities and was more technically capable than its contemporaries, but was five or six times more expensive than a Z80 or 6502.

›› Sound-wise, the MO5 only gets a simple beeper. Rather than using a mouse, an optical pen came with the MO5 as standard. Thomson computers used proprietary parts, and add-ons were expensive. The MO5 was installed in French schools as part of the "Informatique pour tous" (Computing For All) plan. While the French government originally wanted to use the Apple Macintosh, Macs were simply too expensive, and an MO5 was a fifth of the price.

›› Although home users usually bought Thomson models with proper mechanical keyboards, schools were lumbered with cheaper models that used rubber keys.

›› Classrooms made use of the Thomson's special "Nanoréseau" network, where a standard PC would broadcast programs to a network of MO5 terminals. Students were taught BASIC and Logo, which was often used to control a robot tortoise.

3 GAMES

Thomson probably spent and saved money in the wrong areas with the MO5, but it does provide retro gaming fans with something of a different dynamic. A lot of games feel slow, but the MO5 has a fascinating color palette as if someone crossed a ZX Spectrum, Commodore 64, and a Sega SC-3000.

›› Of course, it's hard to find games you can play without the language barrier, but the following shouldn't be too taxing.

›› *Choplifter* (1982) is an arcade classic and a decent conversion, and *Wizball* (1988) and *Enduro Racer* (1988) are surprising, if over-ambitious, inclusions.

›› *La Mine Aux Diamants* (1986) is a great *Boulder Dash* clone for any fans wanting new levels, and *Androides* (1985) is a brutally difficult variation on *Lode Runner*. Fighting fans should try *Yie Ar Kung Fu II* (1986) and *Kung Fou* (1987).

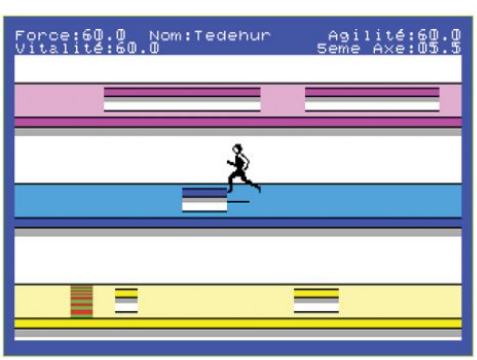
4 LEGACY

Although the MO5 sold well in France, that didn't translate to foreign markets. Improved models were introduced over the following two years, but were soon dropped in favor of 1986's MO6, which had 128KB of RAM and was backward-compatible with the MO5.

›› Unfortunately, Thomson's ubiquity in France was short-lived. Once economic conditions were favorable, Thomson was overtaken by the Amstrad CPC range (France was the Amstrad's most successful territory) and the 16-bit Atari ST. Thomson began selling IBM Compatible PCs in 1987 before leaving the computer market in 1989.

5 EMULATION

While there are other Thomson emulators in existence, when it comes to the MO5, there is really only one choice: DCMOTO.



›› *Le 5eme Axe* (1985, Loriciels) is probably the best game on the system, but you may need Google Translate to hand for the intro.

© LORICIELS

›› **Love it or hate it, the MO5 is definitely a stylish machine – especially its tape drive which has a cool asymmetry to its design.**

›› Although DCMOTO only comes with a Windows binary, Linux users needn't panic, it works perfectly well under Wine. Thomson emulator aside, the DCMOTO website also contains all the Thomson software you're looking for, as well as books, catalogs, documentation, and magazines.

›› To download the emulator, open the DCMOTO home page and click on the Emulator button. Most of the website is in French, but under the blue DCMOTO heading is a button labeled "Download". Click that and a ZIP file will download.

›› Extract the file and inside will be a Windows executable. You will need to open this manually each time, so you may want to make a desktop shortcut if you use DCMOTO often.

6 GETTING STARTED

When starting DCMOTO, there is a help screen in French. Click OK and you'll be taken to the main emulator screen.

›› The first things to do include changing the interface to English, then changing the Thomson model to an MO5.

›› Click the Options button in the main menu and a new window will appear, "DCMOTO paramètres".

›› At the left of the window, towards the middle, is a field called "Langue". Change this from Français to Anglais (English) and click the Appliquer (Apply) button.

›› Now choose the Thomson model from the Computer field around the top of the window.

›› By default, DCMOTO is set to TO9+. There are seven MO5 models to choose from; MO5 v1.1 works best with US keyboards.

›› Choose the 1.1 and click OK. A pop-up will appear saying a reboot is needed. That's just for DCMOTO, not your PC. Click OK.

›› vDCMOTO will now reset into an MO5 BASIC prompt, ready to be programmed or to load software.

7 LOADING CARTRIDGES AND DISKS

Whether you're loading a tape, disk, or cartridge, click "Removable media" in the main menu to get started.

›› Cartridges are the easiest medium to load. Just click the Load button next to the "Cartridge (.rom)" field, choose your file, click Open, and your game will load.

›› While we couldn't find a foolproof way of getting disks to load, we did find a decent method to get your game started, and thankfully MO5 disk software is quite rare.

›› First, you need to enable the external disk drive. Click Options in the main menu, and in the settings window is a field called "Extern controller". Click the option "CD90-351 (3.5in)" then choose OK. Now click "Removable media" from the main menu and press Load to choose a disk image file. Browse for your disk file, then click Open.

›› Reset the MO5 by clicking File → Hard reset. With any luck, your disk will boot itself.

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FRENCH GAMING CHEAT SHEET

joueur(s)	player(s)
charge/chargement	load/loading
appuyez	push
clavier	keyboard
manette	controller
tapez	type
étape	stage
niveau	level
langue	language

8 LOADING TAPES

Tape software is by far the most common format, but getting tapes to load is something of a lottery: so you will probably need to try several commands to load a program.

›› Start by choosing a tape image file from the Removable media window, then click OK.

›› Now you need to try entering a few BASIC load commands—remember to press Enter after each of these commands.

›› The easiest method is to try just entering LOAD by itself. If you're left with an "OK" message and a blinking cursor, enter `RUN`.

›› If that doesn't work, try typing:

```
LOADM"",,R
```

Or in the case of *Le 5eme Axe*, simply:

```
LOADM
```

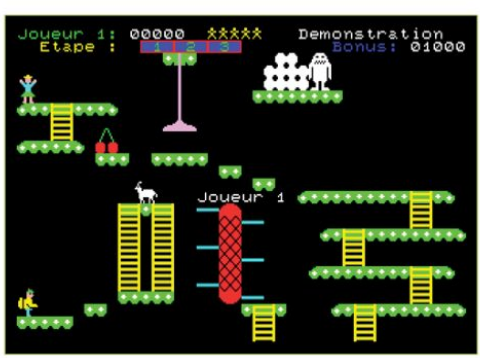
›› If you're using a US keyboard, you will need to press Shift + 2 to type the " character.

›› If none of these commands work, try typing:

```
LOADM "CASS:",R
```

›› On our keyboard, we entered the `:` symbol by pressing `Shift + \`, which should be above the Enter key. If you run into any further problems entering characters, you can bring up a French virtual keyboard by clicking Tools → Keyboard.

›› Lastly, if any program needs a strange command to load, it's worth looking at the filename, which often contains the required load command.



›› ***Yeti*** **(1984, Loriciels) is a great *Donkey Kong* rip-off for the Thomson MO5—and it's arguably better than the original.**

Send online ads down a Pi-Hole

YOU'LL NEED THIS

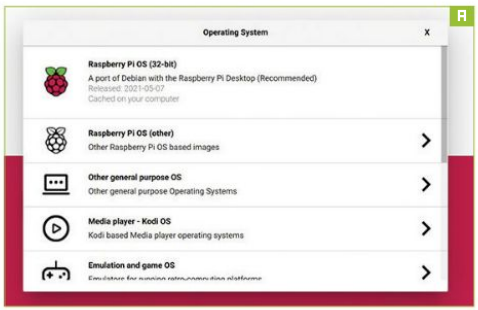
LINUX

Some sort of Linux computer. A Pi Zero is a perfect choice at just $10.

AN ACTUAL HONEST-TO-GOODNESS letter (well, an email) from a reader arrived in the busy *Maximum PC* newsroom recently. Once we'd read it, we were even more shocked to discover it was filled with sensible questions and ideas, rather than the usual offer of manhood-enhancing medication. So thanks to Shawn, without whom we might have written about something completely different this month.

Shawn's suggestion relates to Internet of things (IoT) devices, specifically smart lightbulbs, which he wants to connect to a segmented guest network to deny them full access to the wider internet while keeping their useful functionality. He found he could do this with his guest network, but the presence of a Pi-Hole network ad blocker put a spanner in the works. We'll get to the segmented network part in a later issue, once we've worked out how to do it, but first here's how to set up a Pi-Hole DNS server and never see an online advert again. Except for the ones you whitelist, of course, because ad revenues write writers' checks.

So, the moral of this story is this: please email us. It's not that we're lonely (honest!), it's more that your ideas might just make it into the magazine. –IAN EVENDEN


Operating System
Raspberry Pi OS (32-bit)
A port of Debian with the Raspberry Pi Desktop (Recommended)
Released: 2021-05-07
Cached on your computer
Raspberry Pi OS (other)
Other Raspberry Pi OS based images
Other general purpose OS
Other general purpose Operating Systems
Media player - Kodi OS
Kodi based Media player operating systems
Emulation and game OS

1 PREPARATION

A Pi-Hole is a DNS sinkhole that's used by your router as its domain name server. It strips out traffic from known advertising sites and makes it disappear. As it runs at the network level, it can strip advertising from places such as smart TV UIs and cellphones, as well as the more common website banners and takeovers.

›› This has the benefit of not showing you annoying ads, which also speeds up the loading times of websites. The downside is that ad impressions pay for the web as we know it, meaning that the more we block ads, the less free content there's likely to be in the future. It's a fine balancing act.

›› Pi-Hole is an open-source project that runs on Linux—the officially supported OSes are Raspberry Pi OS, Debian 9 onward, Ubuntu from 16.X, Fedora 32 or later, and CentOS 7 onward. As you're going to want it running all the time, it's recommended that you run it on a low-power device, such as a single-board computer. It will run in a Docker container, or a VM as long as you can give it its own static IP address. It will happily share a machine with a Plex server, so you can kill two birds with one stone. You can even run it on a Raspberry Pi Zero W, but we can't find ours, so we've broken out the Pi 4 instead.

›› And although it is possible to run a Pi-Hole over Wi-Fi, it's better to run it over Ethernet, as it might be handling a lot of traffic. If you want to run it on a Pi Zero, you might want to look into a USB to Ethernet adapter. However you connect, you're going to need to give it a static IP address on whatever you use to dish those out, most likely a DHCP server running on your router.

2 OS INSTALLATION

The Pi-Hole runs on the standard Raspberry Pi OS, so if you need to, fire up the Raspberry Pi Imager and prepare a Micro SD card [**Image A**]. The minimum you need for the regular Raspberry Pi OS is 8GB, or 4GB if you fancy living in a Terminal with Pi OS Lite. With the former, you can leave it running the graphical desktop and take control using VNC.

3 SETUP

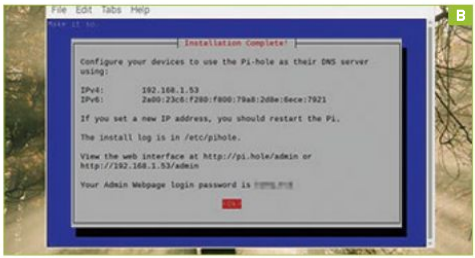
Once you've booted your Pi, let it do its usual thing of downloading updates. You can tinker with the OS's appearance while it does this—our personal preference is to move the menu bar to the bottom, possibly because more than 25 years of using Windows has done something to our brains. Once you've done the inevitable restart, it's time to install the Pi-Hole.

WHITELISTING SITES

The idea of a whitelist is that any sites on the list are passed by untouched by the adblocker. At the risk of sounding preachy, if there's a website you're particularly fond of and visit often, it's worth whitelisting it so that it still makes money from your visits. You will see the ads, but it's a small price to pay for helping make sure your favorite sites don't vanish behind a paywall or close down.

To whitelist a site, head to the web interface and choose whitelist from the left-hand side. Once on the page, add the URL of the site you want in the 'domain' box. If the site has subdomains, it's worth ticking the 'wildcard' box. Press the Add To Whitelist button. That's all there is to it.

© RASPBERRY PI FOUNDATION


File Edit Tabs Help
Installation Complete!
Configure your devices to use the Pi-hole as their DNS server using:
IPv4: 192.168.1.53
IPv6: 2a00:23c6:f280:f800:79a8:2d8e:6ece:7921
If you set a new IP address, you should restart the Pi.
The install log is in /etc/pihole.
View the web interface at http://pi.hole/admin or http://192.168.1.53/admin
Your Admin Webpage login password is
OK
B

4 PI-HOLE INSTALLATION

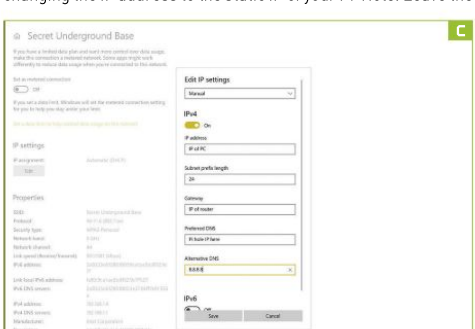
Open Terminal, and type this without the quotation marks: "curl -SSL https://install.pi-hole.net | bash". This is an installation script that takes care of the whole process, with you answering a few questions along the way, such as who you'd like your DNS provider to be, and whether you want the web admin interface to be installed. We chose OpenDNS and said yes to the web interface, as well as accepting all the recommended settings [Image B]. You might also want to write down the web admin password you're given at the end of the process. You can change it using this Terminal command: "pihole -a -p". This is worth doing, as the password generated by the Pi-Hole software will be a random jumble that's difficult to remember.

5 WEB INTERFACE

There's no app to see on the host machine, it doesn't even appear as an entry on the Raspberry menu. Instead, you have a web interface. Open a web browser on any computer attached to your home network, type in the Pi-Hole's IP address (the static one you set earlier), and append /admin. Ours was 192.168.1.53/admin, and yours will be something similar. It's worth exploring the interface, but if you've ever tinkered with the settings of a router, you'll be right at home. Leave it running long enough and you'll get graphs too. There's lots of interesting information to be gleaned from the data—Logitech and Netflix, representing some IoT devices and probably a smart TV or two, are by far the biggest abusers of our internet connection, beating even Google for home-phoning frequency.

6 DNS REDIRECTION

Ideally, you'll change the setting on your router to use the Pi-Hole as the primary DNS server. This is a simple case of finding the relevant setting on your router's web interface and changing the IP address to the static IP of your Pi-Hole. Leave the secondary as it is, so in case the Pi-Hole fails, you won't lose the ability to browse websites completely.



C

›› Doing it this way forces all your internet traffic through the hole, meaning every device that connects is covered. It can strip advertising from smart TV interfaces, YouTube videos, and more. Some ISPs, however, especially those who supply their own hardware, like to lock you out of changing the DNS server. If this is the case, you can change it for a Windows PC by going to Settings → Network & internet → Status and choosing Properties under your active network connection.

›› Under IP Settings, choose Edit, and change from Automatic DHCP to Manual. In the next screen, turn on IPv4, and enter the IP address of your PC (from your router's admin page), followed by a Subnet Prefix Length of 24, the IP of your router under Gateway, and the Pi-Hole IP address in Preferred DNS. Change Alternative DNS to the secondary DNS server you have in your router, or use 8.8.8.8 for Google's DNS service [Image C].

7 LEAVE IT TO IT

And that's all you need to do. If you can't update your router to send all traffic through the Pi-Hole, you will at least be able to use it with any Windows machines, and never see an advert in your browser again. Apart from any whitelisted sites, naturally.

EVENT HORIZON

1. STATUS
A few stats about the host machine, its temperature and memory usage.

2. MENU
Everything you could need lives here on the left, including the ad whitelisting and help.

3. STATS
Headline figures and graphs for what the Pi-Hole has been up to.

4. PI-HOLE MENU
Click here for a link to the developers, or to donate.

5. QUERY TYPES
See the percentage of requests being blocked, and what type they were.

6. PERMITTED AND BLOCKED DOMAINS
Dig down deeper into the details of what's being blocked, and which devices are phoning home.

© XXXXXXXXXXXXX

LAB NOTES

ZAK STOREY, EDITOR-IN-CHIEF

I'm getting Fiber!

All of the internet, all of the time

IT'S HAPPENING. It's finally happening. I'm getting fiber to the property. Hopefully, soon, if I'm lucky. They're digging up the road in my area and installing the good stuff in my town. Contractors are in, and the work is underway, or so I've been told.

I'm currently paying around $62 a month for 145Mb/s down and 17Mb/s up, which isn't too bad. However, once the optical is installed, I should be able to get 900Mb/s up and down for just $68 a month. The only problem is, I'm still stuck in an 18-month contract, so I may have to wait a bit unless I pay to get out early.

It got me thinking though, that is the top package there. Guaranteed averages of 900 up and down, but do I need it? The line I currently have hardly takes an exorbitant amount of time to download games and software, I stream 4K content over it just fine, there's a ton of devices connected all over the house working away over the network, and let's face it, $68 a month is a hefty sum. One that could easily be funneled into a savings account—it's $1,224 over the course of the contract, to be precise.

The "budget" offering comes in at $40 a month and packs in speeds of 300Mb/s down and up, more than twice as fast as I currently get for downloads and 17.6x faster than my current upload speeds.

Admittedly, I'm a fire and forget kinda guy when it comes to software and OS installations. If Windows isn't working quite right, I will format the thing and install fresh, backup-free, and then re-download everything in the process. But is that worth paying the extra per month? I'm not so sure.

Then there's the router conundrum. I want to upgrade my home network too. The Netgear Nighthawk RAXE500 has my attention, a sweet little WiFi 6E number, complete with 2.5Gbps ports, that will go nicely with the Cat7 cables trailing around the house into my office. Pair that with a new NAS and I'll be golden.

But again, at that point, we're talking close to $1000 on a network upgrade, for stuff that I may not necessarily take full advantage of.

Eugh! First world tech problems, eh?

The RAXE500 with WiFi 6E is $600, the WiFi 6 version though? $400

SAM LEWIS

Staff writer

I mentioned previously that I needed to dive straight into some new games. Well, I didn't get very far with that. I was having another look at what was coming out and got excited about *Lego Star Wars: The Skywalker Saga* again. This inevitably turned me back to an absolute classic from my childhood, *Lego Star Wars: The Complete Saga*. So, although my intentions were good, how could I not relive this while it was still fresh in my mind?

This time, however, I wouldn't be playing it on the Nintendo DS as I originally did, but on Steam, and let's just say, it's a little bit of a visual upgrade.

Running through this again after what must be at least 14 years was a great nostalgia trip. There's something about these Lego games that's just so addictive and the mumbling voices are quite hilarious too. Collecting every Lego stud I can see is something I can't get away from. Even though it's time-consuming, it makes these games great for replayability.

After playing through the whole game, I now need to rewatch the films themselves, as that's been a while too. Or continue playing other classic Lego games, until the *Skywalker Saga* comes out. Then I can finally say I am playing a new game.

© NETGEAR, CORSAIR

Editor's Pick:
Corsair K55 RGB Pro XT

The best of the membrane?

IT'S VERY IMPORTANT, when it comes to tech journalism, to stay grounded. It's too easy to play around with all the expensive stuff, and get swept into this world where anything but the best is mediocre. It's a big part of my team's ethos, and something I've drilled into them during my time here. Yeah, RTX 3090s and AMD Ryzen 9 5950Xs are great, but for the vast majority, those ain't nothing more than pipe-dreams, or overly expensive parts that don't warrant the investment.

It's a big part of why our Blueprints section is so important to us as a team, and why we often rotate it between us. That way each of us gets a feel for the industry, and where things lie right now in the market. Over time, and this is something I inherited from my predecessor Alan Dexter, the lower-end parts become the far more interesting items.

After all, we know a Corsair K100 RGB keyboard is going to be impressive, AMD's flagship graphics card will pump out some serious frames, and Audiotechnica's $1000 headset is going to sound great, but how does that tech filter down to the budget options in these manufacturer's lineups? How do the Pentium processors perform? Is integrated graphics improving generation-over-generation? What's happening in the world of non-mechanical keyboards? It's something we don't do enough (not for lack of trying, most manufacturers don't like sending out review samples of budget parts).

And so that's what brought me back to this little number from Corsair. The K55 RGB Pro XT. Despite having a somewhat ridiculous name, it's an intriguing offering from the Californian giant. It features rubber dome, membrane key switches, has six macro keys, dedicated media controls, and some rather impressive per-key lighting as well. Yes, it's membrane, and you can individually control the lighting effects on each key switch if you'd like to.

It's not a perfect solution, there's some bleed over into the surrounding areas, but the fact this is even possible, and not something entirely relegated to the world of individual mechanical key switches, is awesome. It's not that expensive either, you can pick one up for $70 or so. Not super cheap, by any means, but certainly not a $200 juggernaut either. And you get a wrist-rest!

But the big question, no doubt, will be on the feel of the key switches themselves. Do they feel as good as a mechanical switch? No, of course not. If you're used to that super-smooth linear feel, or even the tactile response, this won't be the board for you. It's a tough board to type on for sure. It's quiet, but it requires some force to push each rubber dome down, and there's nowhere near as much travel distance per key switch as you'd find in, say, a Cherry MX Red. That said, actuation is immediate, once the key is traveling, so bottoming out is for your own enjoyment (and also an inevitable side effect of applying enough force to get the key to depress to begin with). And it's also worth mentioning that this thing is pretty quiet too.

Overall, the aesthetic is slick. There's a high-gloss plastic bezel at the top (where the media keys are), then the rest is a fairly budget, smudge-resistant plastic, with the subtle new design style Corsair has debuted in its recent designs. There are a few other basic elements too—there's no USB pass-through, and the cable is a standard plastic, as opposed to being braided, or removable, but otherwise, there's little to complain about. **–ZS**

$70 www.corsair.com

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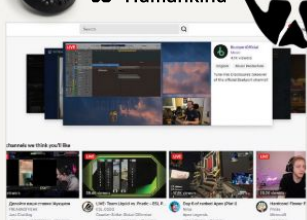


92 Twitch vs YouTube

AMD Radeon RX 6600 XT

Mainstream with a high-end price

AFTER MONTHS OF SPECULATION and waiting, AMD's not-really-budget Navi 23 GPU has arrived in the form of the RX 6600 XT. It brings all the advantages of AMD's RDNA2 architecture, such as the Infinity Cache and ray accelerators, but cut down to manageable sizes. But after nearly a year of GPU shortages, the things we'd really like to see fixed remain a real problem: pricing and availability.

The base model RX 6600 XT cards, including the Sapphire Pulse we're using for this review, supposedly start at $380. There were even cards available at launch for that price, but to the surprise of absolutely no one, those sold out and now we're seeing the RX 6600 XT listed on places such as eBay for $600 or more. Let's be clear: This is not a $600 graphics card. Or rather, it's not a $600 card back in 2019, when the RX 5700 XT came out at $400. In late 2021? Maybe it is a $600 card, at least for those desperately searching for a GPU upgrade.

We mention the 5700 XT because the performance ends up looking similar to that GPU. The 6600 XT comes out ahead at 1080p and 1440p, an impressive feat considering the 8GB of GDDR6 memory is attached via a 128-bit bus—the RX 5700 XT used a 256-bit bus. AMD includes 32MB of Infinity Cache, and while that might seem inadequate, it's still sufficient to beat the previous generation architecture. The uber-high clocks of around 2.5GHz in real-world use help as well.

STUMBLING BLOCKS

After the flash and sizzle of the higher-spec Navi 21 and Navi 22, though, Navi 23 feels a bit stingy. Even Nvidia opted to include 12GB of GDDR6 memory on its competing RTX 3060—though the RTX 3060 Ti, 3070, and 3070 Ti continue to use just 8GB of VRAM. That's probably because 6GB wouldn't have been enough in today's world of increasingly memory-hungry games. The problem is that AMD's RDNA 2 GPUs tend to like having more memory, particularly in a few AMD-promoted games (*Borderlands 3*, *Dirt 5*, and *Godfall*, specifically). With only 8GB and a 128-bit bus, there are times when the RX 6600 XT stumbles.

A prime example of this is if you want the increased realism of ray-traced reflections, global illumination, and shadows. All the grit of ray-traced Night City in *Cyberpunk 2077* proves far too much for the RX 6600 XT, where it manages just 16 fps at 1080p using the RT-Medium preset with RT reflections enabled. The RTX 3060 in contrast plugs along at 31 fps—not great, but still playable, and that's without turning on DLSS. Control does better as it doesn't hit the memory subsystem as hard, but AMD still trails Nvidia in the world of RT gaming. However, there are other games (e.g. *Assassin's Creed Valhalla*) where AMD turns the tables, and overall, we end up with comparable performance.

Sapphire's RX 6600 XT Pulse also performs well in terms of cooling and noise levels. It's not completely silent, but the low 160W TBP means the GPU doesn't need extravagant cooling. The factory overclock doesn't do much to improve performance, but it's guaranteed to work.

The real pain comes when we consider where this card would have launched were it not for the pandemic and cryptocurrency-induced shortages. The previous generation RX 5600 XT launched at $279 in early 2020 and could regularly be found for around $250. Then the world turned upside down and prices skyrocketed. Instead of a $249 launch price with performance matching the previous generation $350 cards, we got a $380 card that sort of delivers new features such as ray tracing support—when it can manage.

Hopefully, things will improve in 2022 and we'll finally start seeing GPUs readily available online for their recommended prices. In the meantime, the RX 6600 XT exists as another GPU that will be difficult to find in stock. **–JARRED WALTON**

BENCHMARKS

	AMD Radeon RX 6600 XT	Nvidia GeForce RTX 3060	Nvidia GeForce RTX 3060 Ti
10 Game Average (fps)	63 / 42	63 / 47	**82 / 60**
Assassin's Creed Valhalla (fps)	**87 / 62**	65 / 50	75 / 61
Borderlands 3 (fps)	**109** / 71	77 / 55	103 / **74**
Control (DXR)	34 / 19	47 / 29	**63 / 40**
Cyberpunk 2077 (DXR)	16 / 6	31 / 19	**42 / 26**
Dirt 5 (fps)	90 / 74	80 / 63	**113 / 86**
Horizon Zero Dawn (fps)	98 / 72	96 / 76	**112 / 89**
Metro Exodus (fps)	74 / 57	65 / 52	**87 / 69**
Red Dead Redemption 2 (fps)	71 / 57	70 / 57	**87 / 72**

Best scores are in bold. All testing conducted with a Core i9-9900K, MSI MEG Z390 ACE, 2x 16GB DDR4-3200 CL16, 2TB XPG 8200 Pro M.2 SSD, Thermaltake Toughpower GF1 1000W. Scores are average frame rates at indicated resolutions.

VERDICT **7**

AMD Radeon RX 6600 XT

+ BRIGHT LIGHTS Good for 1080p; Infinity Cache; efficient.

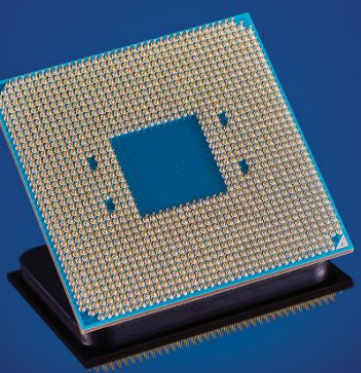
– BIG CITY 8GB feels limiting; weak RT performance; high retail prices.

$380, www.amd.com

SPECIFICATIONS

Architecture	Navi 23
Lithography	TSMC N7
Boost Clock	2589 MHz
GPU Cores	2048
Memory	8GB GDDR6 16Gbps
TFLOPS FP32	10.6
Bandwidth	256 GBps
TDP	160W
Connectors	1x HDMI 2.1, 3x DisplayPort 1.4

The Sapphire Pulse comes with a dual-fan cooler that works well, but without any bling.



Reproduced courtesy of *PC Gamer*. Full review & benchmarks available at https://bit.ly/5700GPCG

AMD Ryzen 7 5700G

APUs make a more than welcome return

STRUGGLING TO FIND a graphics card in these silicon-starved times? AMD suggests that, with the new Ryzen 7 5700G, you might not need one. The Ryzen 5000 series of CPUs have been well received, though, like every other manufacturer of processors and graphics cards, AMD has been affected by wider semiconductor market issues. Limited supply meant that production priority was given to the high-end chips in both the red team's CPU and GPU stacks. That means we haven't seen any really affordable Zen 3-based processors at all, at least not in the retail market.

That doesn't necessarily change with the introduction of the 'Cezanne' family of APUs. The series is led by this beauty, the eight-core Ryzen 7 5700G ($359), which is joined by the hexacore Ryzen 5 5600G ($229) and the quad-core Ryzen 3 5300G. That's a little under the current pricing for the GPU-less Ryzen 7 5800X and Ryzen 5 5600X, and arguably, you get more for your money, too.

Finally, AMD has processors that combine its strong Zen 3 architecture with capable Vega-based integrated graphics. The promise of Zen 3 cores and best-in-class integrated graphics has been eagerly anticipated and we'll be watching to see how fully the 5000G series models filter out into the market.

As for the 5700G's specs. It's a Zen 3-based processor with a 7nm, 180mm2 10.7 billion transistor monolithic die, with eight cores and 16 threads. And by monolithic, we mean that it doesn't match the chiplet design of the other Ryzen 5000-series CPUs. Instead, it squeezes everything into one traditional package design, similar to Intel's designs.

The 5700G has a base frequency of 3.8GHz and a boost frequency of 4.6GHz, yet still has a desirable 65W TDP. But to meet this 65W target, some sacrifices have had to be made; it's not simply a down-clocked 5800X with integrated graphics bolted on. You lose half of the L3 cache and PCIe 4.0 support too. The latter isn't desirable but, apart from losing that peak NVMe SSD performance, much of the target market may not even notice.

The integrated graphics counts as best-in-class, though it's still based on the aging, but reworked and optimized, Vega architecture. That comprises eight compute units, and 512 GCN cores, operating at 2GHz. RDNA-based graphics, not to mention RDNA 2, will have to wait at least one more generation.

Productivity and gaming tasks all take a big step forward over the popular Zen 2 Ryzen 7 3700X. The exception being sequential SSD performance, where the lack of PCIe 4.0 counts against it when put up against the rest of the Ryzen 5000 clique. The 5800X, with its higher boost clock, extra TDP headroom, and increased cache is the better performer.

If you're looking for a powerful HTPC or small machine, a PC for heavy multitasking, or need something with integrated graphics to tide you over until the GPU market returns to normality, the 5700G is an awesome APU. Add a high-end GPU, even a GeForce RTX 3090 or Radeon RX 6900 XT with all the eye candy turned up, and you'd barely lose any real performance compared with any other processor we could mention.

PC gamers have been waiting for Zen 3 APUs, and it's great that they're finally here. You get the strong IPC and multi-threaded prowess that Zen 3 brings to the table, paired with top-end integrated graphics. You can run a monitor or two and enjoy some basic gaming, or even better, true gaming with older or esport titles, while keeping around a 65W TDP. If you're looking for a high-performing jack of all trades, AMD's Ryzen 7 5700G is tough to beat. **–CHRIS SZEWCZYK**

VERDICT

9

KICK ASS!

AMD Ryzen 7 5700G

+ PRODIGAL SON Epic iGPU, Excellent Thermals & Power, Strong all-round performance.

– WOEFUL CHILD Lacks PCIe 4.0.

$360, www.amd.com

BENCHMARKS

	AMD Ryzen 7 5700G	AMD Ryzen 7 5800X
CineBench R20 Single (Index)	580	**617**
CineBench R20 Multi (Index)	5,468	**6,013**
Tech ARP's x264 (avg fps)	47.69	**52.42**
Metro Exodus @ 1080p (avg fps)	120	**127**
Civilization VI @ 1080p (avg fps)	241	**252**
3DMark Time Spy Extreme (Index)	7,883	**8,238**
Price Per Thread ($)	**$22.50**	$28.13
Recommended Retail Price ($)	**$360**	$450

Best scores in bold. Test bed consists of an ASRock B550 Taichi Razer Edition, MSI GeForce RTX 3080 Gaming X Trio, 16GB DDR4 @ 3200, 500GB Samsung 980 Pro PCIe 4.0 M.2 SSD, and a Corsair H100i Pro 240mm AIO. All games tested on the Ultra preset on DX12. Prices (USD) correct at time of writing.

SPECIFICATIONS

Cores / Threads	8 / 16
Base / Turbo Clock	3.8 / 4.6GHz
Architecture	Zen 3
Lithography	TSMC 7nm
Memory Support	DDR4-3200
PCIe Support	PCIe 3.0 x8x4x8
Integrated Graphics	RX Vega 8
TDP	65W

The MSI Katana GF66 certainly looks sharp

MSI Katana GF66

Is this budget laptop really a double-edged sword?

MSI MAKES SEVERAL decent-performing laptops that offer plenty of bang for your buck, especially at the budget end of the market. Other elements of the company's laptops let them down though and often hold MSI back from getting rave reviews. We understand that you can't expect perfection at this price range, but with the MSI Katana GF66 laptop sitting squarely in the budget bracket, can this model cut through these preconceptions?

It looks pretty similar to other MSI products in this range, especially the Bravo 15 laptop we reviewed earlier this year. Its slightly angular all-black design creates some sharp chassis lines that make the laptop stand out from the crowd. Straight out the box, it looks utilitarian and feels pretty rugged and sturdy. It's not the sleekest looking thing, but it is slim enough to pack away in a backpack. Nor is it the lightest laptop, so bear that in mind if you're likely to be carrying it around with you.

Opening the lid creates a gap between the hinge and the main chassis which is a nice touch and provides better cooling. Due to it being rugged and fairly heavy, there isn't much screen wobble. The screen isn't the most modern of designs due to a slight clamshell top bezel and a thick chin on the bottom. However, at least the top bezel houses a webcam, and the side bezels are fairly slim. The 720p webcam is nothing to shout about, but it does the job for generic video calling, with a frame rate of 30fps. The screen is pretty impressive for the price, with the 15.6" IPS display delivering a Full HD resolution. The color reproduction is pretty good, and although it's vibrant enough, it could do with being a bit brighter on the whole. Thankfully this panel has a refresh rate of 144Hz, which certainly makes everything feel smoother, especially gaming.

MSI's keyboards are, on the whole, pretty good for a laptop and the full-sized one on the Katana GF66 doesn't disappoint. The red backlit keys match the theme well and key travel is pretty deep for a satisfying feel and sound when typing or gaming. It features MSI's font, which matches the aesthetic. Unfortunately, the trackpad is a little underwhelming, clicking on it isn't as satisfying as the keyboard, but it has a nice soft touch to it. In any case, we would always recommend opting for a mouse for a much better experience.

KEEPING COOL

The main chassis offers a generous amount of cooling exhausts to keep the laptop running at a decent temperature. The port selection is just as generous. On the left side of the laptop, there is a DC input, a USB 2.0 type A and also a USB 3.2 type A. On the right, there's another USB 3.2 type A, an HDMI and ethernet port, an audio jack, and a USB C 3.1 gen 1 port. This should be more than enough to connect other peripherals to this laptop.

Overall, the laptop holds up well compared with others in this price range, with solid build quality, a satisfying keyboard, and a nice-looking screen but, of course, the key is in the performance.

Here, it is impressive, to say the least. If you are looking to play games with high presets and want a good frame rate then the MSI Katana GF66 will provide that. Our model with the RTX 3060 and Intel's 11th gen i7-11800H should be safe to future-proof and is Windows 11 compatible, which is a big thumbs up for MSI.

While testing benchmarks, the Katana GF66 performs reliably and, paired with the 144Hz panel, gaming is a blast. Considering the lower price tag of this laptop, it doesn't disappoint. First-person shooters are buttery smooth and the performance is everything you could want from a laptop. Gameplay is easily over the 60fps mark and, on a budget machine, that's a pleasant surprise.

Overall, the MSI Katana GF66 manages to cut through the preconceptions of previous models. It is a well-balanced, gaming laptop with enough punching power to be no problem to play on, even at high presets. The few minor gripes come down to the materials used, the laptop being a little clunky, and the weak speakers. It isn't the most polished laptop, but at this price, it does a good job at what it's intended for. **–SAM LEWIS**

VERDICT **8**

MSI Katana GF66

CUTS DEEP Decent keyboard; great gaming performance; futureproof for Windows 11.

LITTLE BIT BLUNT Weak speakers; underwhelming trackpad; a little hefty.

$1,399.99 www.microcenter.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	1,352 (31%)
CrystalDisk Q32T1 Sequential Read (MB/s)	3,374	1,982 (-41%)
CrystalDisk Q32T1 Sequential Write (MB/s)	2,530	1,348 (-47%)
3DMark: Fire Strike (Index)	13,610	16,696 (23%)
Rise of the Tomb Raider (fps)	92	118 (28%)
Total War: Warhammer II (fps)	62	82 (32%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	89 (82%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

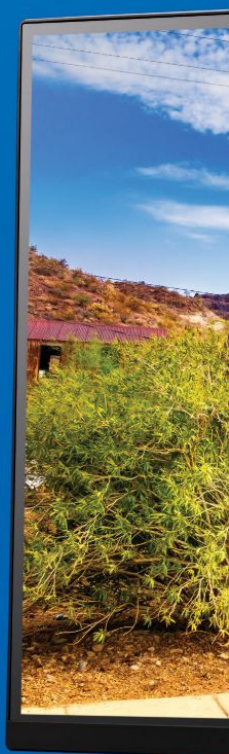
Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	Intel i7-11800H @ 2.30GHz
Graphics	Nvidia GeForce RTX 3060 GDDR6 6GB
RAM	16GB DDR4 @ 3200MHz
Screen	15.6" Full HD IPS @ 144Hz
Storage	512GB SSD
Ports	1x USB 3.2 Gen 1 Type-C, 2x USB 3.2 Gen 1 Type-A, 1x USB 2.0 Type-A, 1x HDMI, 1x audio combo-jack, 1x Gigabit Ethernet
Connectivity	Wi-Fi 6 802.11ax, Bluetooth 5.2
Weight	4.96lbs
Size	0.9 x 10.2 x 14.1 inches

Razer Raptor 27

Is Razer's refreshed Raptor good enough to justify its painfully premium pricing?



RAZER'S RAPTOR 27 was already one of the sleekest and most desirable gaming panels on the planet, certainly in the 27-inch class. Now Razer has given it a nip and tuck to keep it relevant in the fast-moving monitor market. The new model is a dead ringer for Razer's Raptor 27 monitor, with the same all-black minimalist design and lush forged aluminum stand, complete with novel cable management. Included are a set of bright green proprietary cables, one each for the Raptor's interfaces including power, video inputs, and USB connectivity.

These flat cables are designed to slot into the channels on the rear of the tilt and height-adjustable stand, which are covered by removable slats. HDMI, DisplayPort, and USB-C are included, and the latter supports both device charging and the full 165Hz refresh.

Outstanding industrial design sets the Raptor 27 apart from more mainstream gaming screens. Along with the gorgeous build quality and unusual ergonomics, the Raptor 27 has a few neat features, such as the fabric covering on the rear and RGB lighting that's far better integrated than the norm. Razer's signature Chroma RGB feature is built into the bottom of the stand, giving the impression that the monitor is sitting on a slice of light. The sophisticated look is a trick many PC peripheral manufacturers fail to pull off.

As for those upgrades, the most obvious is a jump from 144Hz refresh for the 1440p IPS panel to 165Hz. The Raptor 27 is also party to THX certification (for image quality and precision) to go with the VESA DisplayHDR 400 accolade the previous iteration attained. There are few other changes, but the Raptor 27 already knocked out some decent numbers, such as 1ms responses, 420 nits of brightness, and 95 percent coverage of the DCI-P3 digital cinema color space.

So, how does the viewing experience stack up? No question, this is a punchy, vibrant panel. In SDR mode, it has plenty of fizz, with lovely saturated colors and decent contrast, though the IPS panel technology doesn't allow for black levels as deep and inky as the best VA screens.

The Raptor's HDR performance is a little less convincing. The good news is that SDR content looks good in HDR mode, so you don't have to jump between settings, but depending on the HDR content, it isn't always successful. *Cyberpunk 2077* has more depth and visual clout in SDR mode. In HDR mode, general brightness levels are subdued.

As for pixel response, Razer has included two levels of overdrive. Even the fastest setting suffers little visible overshoot. Overall, the experience doesn't feel quite as sharp and blur-free as the fastest IPS monitors. But, combined with the static image quality, the Raptor is up there with the best 1440p gaming panels by most measures.

Except, of course, at 165Hz even this updated Raptor is miles behind the fastest 240Hz 1440p panels. Returns arguably diminish pretty rapidly above 144Hz for most gamers. But this is a seriously pricey panel, so any perceived shortcomings take on added importance.

It's the gap between what you can get at this price and what the Raptor delivers that's the problem. For this money, you could have a 4K 144Hz monitor, and not far off a 120Hz OLED TV. It's not a direct comparison, but a reminder of how much of a premium you're paying for the slick design and quality build. **–JEREMY LAIRD**

VERDICT **9**

Razer Raptor 27

+ VELOCIRAPTOR Lush 165Hz IPS panel; fantastic design and build quality.

– FOSSILIZED REMAINS Megabucks for a 1440p panel; limited HDR performance.

$799 www.razer.com

SPECIFICATIONS

Panel size	27-inch
Panel type	IPS
Resolution	2,560 x 1,440
Brightness	420 nits
Colour coverage	95% DCI-P3
Refresh	165Hz
Contrast	1,000:1
Response	1ms
Inputs	1x HDMI 2.0b, 1x DisplayPort 1.4, USB-C with DP 1.4 Alt Mode

The Razer Raptor 27 is beautifully built. But for $799, it needs to be...

The PNY XLR8 CS3140 is available either with or without the hefty cooler

PNY XLR8 CS3140 1TB

Can PNY's fat new SSD keep cool under pressure from its rivals?

SOME SSD MANUFACTURERS go into forensic detail when it comes to the speeds and feeds for their latest and greatest M.2 drive. But not PNY. The new PNY XLR8 CS3140, reviewed here in 1TB trim and also available with a tasty 2TB of storage, is a case in point.

No question, we know it's a high-end model, with the quad-lane PCIe Gen 4 interface, claimed read speeds up to 7,500MB/s, proper TLC flash memory rather than cheap QLC chips, and that big, fat heat sink. Indeed, it's faster on paper than both Sabrent's Rocket 4 Plus and the Samsung 980 Pro, both of which are pegged at 7,000MB/s. It's even a whisker ahead of the Adata XPG Gammix S70, which tops out at 7,400MB/s.

That kind of raw pace is also beginning to bump up against the theoretical 8GB/s limit of quad-lane PCI Express 4.0 interface. But as far as the details go, that's about it. Okay, PNY also quotes sequential writes speeds, 5,650MB/s for this 1TB model and 6,850MB/s for the 2TB. But it conspicuously doesn't list random access IOPS performance or much by way of configuration details.

What's the controller chipset? How about write endurance? The XLR8 CS3140 comes with a five-year warranty, so you could argue the specifics of aspects such as write endurance are academic. But no matter, we can confirm the XLR8 CS3140 sports a Phison PS5018-E18 controller and four 256GB packages of Micron 96-Layer 3D TLC NAND.

The former is the same chip you'll find in the Sabrent Rocket 4 Plus. As we've previously observed, the E18 is an eight-channel NVMe 1.4 chip cranked out on TSMC's 12nm process and packing five cores, three generic ARM Cortex R5 designs, and two proprietary Phison items. According to Phison, the E18 is good for 7.4GB/s read and 7GB/s write speeds, plus the minor matter of one million IOPS.

In other words, it's pretty much state of the art by client PC SSD standards. So, you'd have thought PNY would be happy to list it in the spec sheet. The same goes for the 1GB of DDR4 cache memory. But enough with the specs, what about the XLR8 CS3140's actual performance?

Perhaps unsurprisingly, it mirrors the Sabrent Rocket 4 Plus across most of our standard benchmark suite. So, peak throughput is bang on the Sabrent's claimed 7,000MB/s performance rather than the 7,500MB/s PNY lists. Write speeds are lower than the Sabrent's, but then the Rocket 4 Plus was reviewed in the faster 2TB configuration.

With the 4K IOPS performance, there's nothing in it—which is to say that this drive puts out numbers that are excellent, but not absolutely at the leading edge of what a flash-based SSD can currently achieve. For that, you'd want WD's Black SN850, albeit the delta isn't huge. For a big step up in IOPS performance, only Intel's Optane drives with their exotic 3D Xpoint phase-change memory will deliver.

As for sustained performance, during our pre-flight drive filling procedure, the XLR8 maintained its initial internal file copy performance of around 1.7GB/s for fully 300GB before dropping to between 400MB/s and 800MB/s. The drive stays cool throughout, topping out at a mere 36°C. So, that big, fat heat sink really works and the 300GB/s performance cliff, which is eminently acceptable, is a consequence of the size of the drive's SLC cache rather than any thermal throttling.

The new PNY XLR8 CS3140 is therefore a strong all-round performer based on proven technology and backed by a lengthy warranty. As things stand, the XLR8 and the Sabrent Rocket are both available for $179, with the heat sink adding another $10, a premium we'd be tempted to pay. The only slight snag is that the WD Black SN850 is also available for $189 and is such a classy all-round SSD, we'd find it hard to overlook.

–JEREMY LAIRD

VERDICT 8

PNY XLR8 CS3140 1TB

+ HEAVYWEIGHT CHAMP Great all-round performance; cooler actually works.

– MORBIDLY OBESE Not actually outstanding by any metric

$189 www.pny.com

SSD BENCHMARKS

	PNY XLR8 CS3140 1TB	Samsung 980 Pro 1TB	Sabrent Rocket 4 Plus 1TB
CrystalDisk 6 Sequential Read (MB/s)	7,002	**7,098**	7075
CrystalDisk 6 Sequential Write (MB/s)	5,260	5,172	**6836**
Anvil 4K QD 1 Read/Write (MB/s)	68 / 236	**83** / 194	68 / **239**
Anvil 4K QD 2 Read/Write (MB/s)	140 / 412	**168** / 384	134 / **435**
Anvil 4K QD 2 Read/Write (MB/s)	260 / **733**	**328** / 648	265 / 708
Final Fantasy XIV: Shadowbringers (load time seconds)	11.6	9.902	**8.979**

Our test bench consists of an AMD Ryzen 7 3800X, an Asus Crosshair VIII Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD. Best scores are in bold.

SPECIFICATIONS

Capacity	1TB
Form factor	M.2 2280
Interface	PCIe 3.0 x4
Protocol	NVMe 1.4
Read / write speed	7600 / 5650 MB/s
DRAM cache	1GB DDR4
SLC cache	300GB (estimated)
Write endurance	N/A
Warranty	5 years

Asus ROG GS-AX5400

Strix router is bettered by ProArt equivalent

WE'VE GOT SOMETHING a little bit different for you—a router. For the first time in a while, we're starting up our router reviews again. Now, you'll have to bear with us, as this format and its associated benchmark testing is likely to change quite dramatically over the next year or so, but it's an area that we want to iron out properly and get more into the mag.

So, what have we got here? This is Asus's latest ROG GS-AX5400 WiFi 6 router, a somewhat premium offering, clocking in at just shy of $250. Being part of the ROG Strix lineup, it's definitely a more 'gaming-centric' device and the design very much screams that.

There's a bold holographic ROG logo on the top (thankfully not RGB), followed by some (sadly RGB) lighting running around the sides, and then four little white LED lights on the top left to indicate power, 2.4GHz, 5GHz, and WAN connectivity status. It also features four antennas to improve WiFi 5 and WiFi 6 performance, and for rear I/O, you have access to a 1Gb/s WAN port, 4x 1Gb/s ethernet ports, a USB 3.2 port, and that's about it.

As for tech features, those used to the Asus firmware will be well at home here. There's access to the Network Map, guest network setup, AI protection, Adaptive QoS (for smart bandwidth allocation), Traffic analysis, various Open NAT, and Game optimization features. Alongside that are the usual Wireless, LAN, WAN, IPv6, VPN, Firewalls and other configuration tools now well established in the Asus ecosystem (we'll have a few software versus, comparing these firmwares in detail over coming issues).

Wi-Fi encryption extends up to WPA-3, and there's also support for MAC filtering, and multiple guest networks too (up to three separate guest networks per frequency band). As for the hardware, you get a 1.5GHz tri-core processor, 512MB of RAM, and 256MB of flash memory.

We did some basic testing with this one, across both wired and wireless connections, using speedtest.net as our primary test facility. Perhaps unsurprisingly when operating in wired mode, the performance compared to our regular AX88U across multiple runs was within margin of error. Both devices achieved a ping of 13ms, and download speeds of 148.57Mb/s for the AX88U, and 149.82Mb/s for the AX5400. Meanwhile, the upload speeds were far closer, at 17.33 and 17.1Mb/s respectively.

Moving on to the WiFi 6 testing, however, and that's where things began to come unstuck. The router is positioned downstairs in the living room, with our office directly above it. Using the Speed Test app on our Samsung Galaxy S21 Ultra, we performed multiple runs, using the same server and configuration in the same location in the office as before. We noticed repeatedly that, despite both routers having around the same signal strength over WiFi 6, the AX5400 scored on average, a measly 33.6 down, and 17.3 up with a ping of 15ms. That's in contrast to the AX88U, which packed in repeated runs of 124Mb/s down and 17.1 up, with a ping of 15ms too.

SETTLING SCORES

Eliminating the interference and moving the phone directly next to the router didn't entirely alleviate the symptoms either, nor did disabling every other wireless device in the house. Scores improved, but only up to 80Mb/s down, nowhere near the 120+ achieved by its ProArt cousin. Now, this could be down to poorer quality antennas (although Wi-Fi signal strength was perceivably the same on both routers), or a firmware glitch (both are using official Asus variants for testing), however, no matter what we did, over multiple attempts and reconfigurations, we just couldn't get the AX5400 anywhere close to the AX88U on Wi-Fi performance.

For a router that touts WiFi 6 support as one of its main selling features with bandwidth up to 4,804Mb/s (a spec that's identical in the AX88U), that doesn't bode well. Admittedly, the AX88U costs $75 more, features a quad-core processor, and has a far more mature firmware, but even so, that's a huge return in investment for a wireless device performance that's so much better in comparison.

So, who is this aimed at exactly? If you're a gamer, at college, or have a small apartment, and just can't stump up for the more premium offerings, it's a reasonable choice. Wired performance is certainly there, and the feature set inside the UI firmware is exceptional, but if you can spare the cash, the AX88U and Asus's less gamer-focused offerings will serve you much better. **–ZAK STOREY**

VERDICT **7**

Asus ROG Strix GS-AX5400

ALL THE GEAR Extensive firmware suite; decent design; good security; small footprint.

NO IDEA Poor WiFi 6 performance; gamer-type design could put some off.

$250 www.asus.com

SPECIFICATIONS

Wireless	2.4GHz N 2x2, 5GHz AC 4x4, 2.4GHz AX 2x2, 5GHz AX 4x4
Wi-Fi Encryption	WPA3-Personal, WPA2-Personal, WPA-Personal, WPA-Enterprise , WPA2-Enterprise , WPS support
CPU	1.5GHz Tri-core processor
RAM	512MB
Storage	256MB Flash
Ports	1x RJ45 WAN, 4x RJ45 LAN, 1x USB 3.2 Gen1

Definitely a gaming router.

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HyperX Alloy Origins 60

Big things come in small packages

UNBOXING and handling HyperX's latest 60 percent keyboard is an absolute joy. This feels like a premium product from the start, with a sturdy aluminum chassis and multi-level rubber feet that keep it completely stationary on any surface. The keycaps are doubleshot PBT, with a matte surface that feels comfortable and grippy under the fingertips. A simple but durable braided cable connects via a USB-C port on the rear of the keyboard to a USB-A port on your PC or laptop.

Imagine how happy we were to find out that this dinky, but robust, keyboard only costs a hundred bucks! Sure, it's still pretty far from the budget keyboard space, but looking at the competition from brands like Asus, Razer, and Ducky, it's hard to argue with that price point.

So, what does $100 get you? The Alloy Origins 60 is a fairly conventional compact keyboard in terms of layout, chopping off the function keys and everything east of backspace to end up with 61 keys. There are no fancy macro keys here, and media controls (and some other functions) are relegated to alt-functions printed clearly on the fronts of the keycaps.

The aesthetics of this keyboard are just as good as its big brother (the original Origins) thanks to vibrant per-key RGB lighting. A funky alternate spacebar with a topographic design comes included in the box, which looks fantastic, although it's worth noting that this is made of a cheaper-feeling ABS plastic rather than the high-quality PBT of the other keys.

The key switches on offer here are HyperX's own proprietary mechanical switches, which are rated for up to 80 million keypresses. The Alloy Origins 60 only comes with linear red switches, which will likely be a dealbreaker for those who prefer clicky blue or tactile brown keys instead. These switches seem a little louder on full keypresses than their Cherry MX Red counterparts, but this could be due to the lower travel.

SNAPPY RESPONSES

That said, these proprietary red switches feel fantastic to use. A force of 45g and an actuation point of 1.8mm (considering the total travel distance of 3.8mm) mean that these keys feel snappy and responsive in games, but without the featherweight triggering of some linear switches. There's little wobble in the key stems, too. Overall, it makes for a much better typing experience as well as excellent, lightning-fast gaming performance.

This is still very much a gaming-oriented product, but it's great to see a 60 percent gaming keyboard that is still viable for a productivity space. The compact size has its upsides and downsides; at less than 12-inches across, it takes up little real estate on your desk, but the lack of features like arrow keys does pose something of an adjustment period. Most 'missing' keys are used by holding down Fn and hitting the key with the corresponding function printed on the front face. While this feels cumbersome at first, it soon becomes muscle memory.

Customization is handled by HyperX's own NGenuity software. It's a fairly straightforward program to use, letting you easily rebind keys or customize the per-key RGB, but the profile-swapping function still needs a bit of work; you can store up to three profiles on the keyboard's onboard memory, but keeping track of which profiles are active and loaded isn't immediately obvious. You can also swap between a handful of lighting presets (and adjust the RGB brightness) using dedicated alt-key functions, which bypasses the need for NGenuity.

Ultimately, we have few criticisms of the Alloy Origins 60—or at least, few criticisms that can't be leveled at any 60 percent keyboard. Its compact size, onboard memory, and detachable cable make it highly portable, an excellent choice for attending a LAN party (only once you have got your COVID jab, mind).

While we hope that HyperX introduces an option for different key switches in the future, this is still one of the best compact keyboards available right now. If you like your keys linear and desperately need to free up some desk space, this is the keyboard for you. –CHRISTIAN GUYTON

VERDICT **9** KICK ASS!

HyperX Alloy Origins 60

+ **ORIGINAL** Great value; top-notch build quality; HyperX red switches feel great to use.

– **REHASH** No tactile or clicky switch options; layout can initially take some getting used to

$100, hyperx.com

SPECIFICATIONS

Switch Type	HyperX Linear Red Switch
Switch Durability	80 million presses
Media Keys	Integrated alt-keys
Connection	USB-C to USB-A
Battery Life	N/A
Wrist-rest	N/A
Dimensions	11.7 x 4.2 x 1.5 inches

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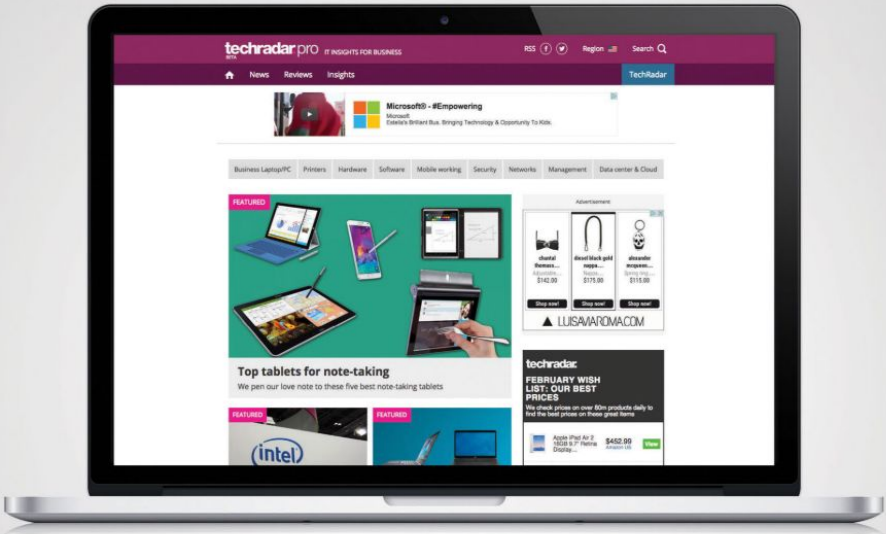
IT INSIGHTS FOR BUSINESS



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Steelseries Arctis Prime

A worthy addition to Steelseries' pro range

THE ARCTIS HEADSET line certainly features many variants, and on the whole, the range has been well received. Steelseries even states on the box that 'Arctis headsets win more awards than any other brand', which is an impressive claim. The line spans a wide price range from $50 to above the $200 mark, and with the models all looking fairly similar, you can generally expect better quality and features the higher up the range you go. The Arctis Prime is a budget headset costing just under $100. It's part of the Steelseries prime series of peripherals produced in conjunction with top esports players, so it should be pretty decent for gaming. Is this is the headset you should be picking out of the Arctis lineup?

The Arctis Prime headset looks similar to the rest of the lineup but features the 'ski goggle headband' that isn't seen on the other budget headsets in the series. The elasticated band rests on your head suspending the headset—we love this style of headband, it's one of the most comfortable out there. In fact, the Arctis Prime is just as nice to wear as the more expensive Arctis 9 we tested, which also features the same headband. The Prime has 'leather-like ear cushions' that feel more premium than the fabric cushion on the Arctis 9. In addition to the lightweight construction, this makes for a comfortable peripheral.

The design is similar to the rest of the headsets in the Arctis range, and this can only be another positive for the Prime headset. The cans aren't too large and they sit nice and flush with the headset. The color scheme is an all-black matte finish and everything feels well put together with plenty of stable adjustment. So with plenty of boxes already being ticked, we're off to an exciting start, particularly for a budget headset. However, it's the sound quality that really matters, of course.

In short, they don't sound bad at all. With a deep, full soundstage, they create a great atmospheric experience. Gaming with these on is enjoyable and what you would hope for from a 'high-fidelity esports headset'. They are clear when you need them to be in competitive gameplay, but also rich with a heavy bass when immersed in story-type gameplay, which is the best of both worlds. Though they aren't the greatest we have heard, at this price, they are pretty impressive.

The low-end is the best part of the Arctis Prime's sound, with plenty of deep thumping bass and solid thwacks. Though that comes a little at the expense of the high-end, particularly the amount of detail, they are under 100 bucks and, at this price, we can't really complain about the overall sound quality.

REDEEMING FEATURES

Perhaps the one thing that lets the Arctis Prime down is a lack of features. Wireless connectivity is missing and there aren't many controls either. The headset comes with two cables, including a detachable 3.5mm cable compatible with PC, Xbox, PlayStation, and Switch. There is also a dual 3.5mm extension cable for desktop PCs, which is a nice touch.

On the left cup, you'll find the retractable microphone, mute button, volume wheel, 3.5mm jack, and the main cable port. The microphone is particularly good for gaming, with the audio pickup as reasonable as you could hope for at this price, making communicating with teammates a breeze.

In terms of features, this headset is pretty bare. It lacks playback/volume control on the cable, which is a shame, and while they don't feature active noise cancellation, there is a fair amount of noise isolation from the headset itself, which aids the gaming experience.

For under $100, this is a great headset that does exactly what you'd expect from Steelseries. It is a little too bass-heavy for listening to music, but having been designed with the help of esports gamers, and from the quality and directional audio alone, it's clear that isn't the intended use. While it lacks wireless connectivity, there are other wireless headphones in Steelseries's arsenal to choose from. This budget gaming headset has a lot to offer, a decent soundstage, and great system compatibility. –SAM LEWIS

VERDICT **9**

Steelseries Arctis Prime Headset

PRIME EXAMPLE Premium build quality; accurate microphone; great comfort; impressive sound.

NEARLY THERE Lacking a few features; no wireless support.

$100, www.steelseries.com

SPECIFICATIONS

Driver Type	Custom 40mm neodymium driver
Frequency Response	10Hz-40,000Hz
Impedance	32 ohms
Connectivity	Auxiliary cable
Compatibility	PC, Mac, Playstation, Xbox, Nintendo Switch, Mobile
Battery life	Up to 20 hours
Design Style	Closed back

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HyperX Pulsefire Haste

Lightweight legend

OH, THAT HONEYCOMB design isn't going away, is it? It's been adopted by virtually every manufacturer trying to produce an ultra-lightweight gaming mouse, and for good reason; it allows for better airflow and reduces overall weight significantly without sacrificing structural integrity. It also looks cool as heck, if you like your sci-fi architecture to focus on hexagons rather than circles or triangles.

Visually, this is a pretty basic mouse. Besides the hex-patterned perforation, there's little to focus on; just a subtle HyperX logo beneath the two thumb buttons and a single LED that illuminates the scroll wheel. This is distinctly a gaming product, but not an ostentatious one. The honeycomb holes extend up onto the back edge of the two main buttons, and a tiny DPI adjustment button nestles behind the scroll wheel. There's no thumb rest, and lefties are left out in the cold as per usual.

Fortunately, this bog-standard layout belies a more complex interior. The left and right mouse buttons house TTC Golden micro dustproof switches rated for up to 60 million presses, which (as the name suggests) are coated in a dust shield. It's an ideal inclusion, given the perforated casing's propensity to gather dust and debris after extended use. If you like to eat at your desk, we advise investing in some compressed air and an extra-narrow nozzle.

The sensor powering the Pulsefire Haste is a PAW3335 from PixArt, which offers a maximum DPI of 16,000. That's easily enough for the average user, with only the most twitchy of esports pros likely to turn their noses up at it. Considering the $50 price point, it's a reasonable package. There's no unique selling point here; it's just a good mouse that doesn't weigh much.

So how lightweight is the Haste? It weighs in at just 2.1 ounces (59g) without the cable or 2.8oz (80g) with it. That's certainly deserving of the 'lightweight' label, and combined with the ultra-low-friction PTFE feet, it glides effortlessly over any desk surface. The cable will be familiar to anyone who has handled a HyperX mouse before, a flexible black paracord material that shouldn't impede regular use. It isn't detachable, but that's hardly surprising; wireless technology would weigh down this mouse.

GRIPPING STUFF

Contained in the box, there is an extra set of PTFE pads (if you're planning on hitting that 60 million click limit, you'll need to replace them at some point) and, more interestingly, a set of specially shaped grip tapes that can be adhered to the buttons and sides. These significantly improve the grip of the mouse's matte casing, which will prove invaluable for claw and fingertip grip users. The grip tape has a hexagonal patterning to match the chassis, which is a nice touch.

As expected, HyperX's NGenuity software can be used to tweak the settings. Ultimately this comes down to adjusting the DPI profiles and RGB lighting, but it hardly feels like a necessary download when five DPI presets come loaded onto the mouse straight out of the box and there's only one RGB zone to edit, which defaults to the expected rainbow pulse. Onboard memory means you can save one setting profile to the mouse, which is handy if you're using it with multiple devices.

The Haste isn't that unique, but it does what it sets out to do near-perfectly. Most competitors in the ultralight gaming mouse arena are more expensive, such as the Roccat Kone Pro or the Steelseries Aerox 3, or end up having to make sacrifices in either performance or design. It's swiftly becoming a busy market space and, while we'd readily admit that the Haste doesn't do enough to stand out from the crowd, it's still one of the best options available.

For those who prefer a weightier mouse—this reviewer uses a chunky Logitech G502 Lightspeed with 8g of extra weights slotted into the underside—the Pulsefire Haste is never going to hit the spot. If what you want is featherweight handling for gaming, though, this could be the mouse for you. –CHRISTIAN GUYTON

VERDICT **9**

HyperX Pulsefire Haste

+ HASTY Super lightweight; understated appearance; solid sensor; great feet and grip pads.

– SLUGGISH Dust buildup could be an issue; lacks unique features.

$50, hyperx.com

SPECIFICATIONS

Sensor	PixArt PAW3335
Sensitivity	16,000 DPI
Speed	450 IPS
Polling Rate	1000Hz
Programmable Buttons	6
LEDs	1x RGB zone
Cable Length	180cm
Weight	2.1oz (without cable)

Humankind

Human kind. Bear ferocious. Egyptian chariot terrifying.

YOU CAN'T WRITE about historical 4X games without mentioning *Civilization*, and yes, *Humankind* is, on the surface, a bit like *Civilization*. There's a hex grid you can hide, you start in the stone age, and given half a chance, your neighbor will move its tanks into your capital even though you've been trading resources amicably for years.

One major difference, though, is that there's only one way to win a game of *Humankind*. Another is that it's a race. *Humankind* differs from *Civilization* in that you don't play as the same culture all the way through (unless you want to), but pick and choose from available societies depending on what your aims are in the next era. So a good solid foundation in food and population growth in the Ancient era as the Harappans (who get food-growing bonuses) can see you pivot to industrial expansionism in the Classical era as you become the Maya.

That is if someone else hasn't got there first. We said it was a race, and the first to win seven stars in the current era gets to leave it first and has first pick of the cultures available for the next one. No two cultures can be the same, so if you desperately want the Medieval Franks with their influence bonus (useful for founding new settlements) then you have to get there first, or it might not be available when you do.

This is hugely frustrating if you have a plan, but leads to some delicious U-turns and reallocations of resources when you have to settle for second best because the Hittites discovered more curiosities (interesting things scattered around the world to be discovered by mobile units in the early phase of the game) than you did.

War is definitely part of the game, playing out on a small tactical map within the broader world map, and with an auto-resolve option. It's a bit too easy to get into the finer details of your trade treaty with the Huns only to find a Carthaginian chariot sitting in your capital city before you've had the chance to build any walls—but a simple military takeover isn't a way you can win. Nor is sticking up wonders of the world for a cultural victory, nor sending a mission to Mars, nor filling in every gap on the tech tree, not hitting the turn limit of 300. You'll have to do all of these, somewhere along the line, as the only way to win is by earning fame.

Fame comes as you earn era stars by accomplishing feats with your culture. If you're getting too far behind, the game will sometimes award you a 'competitive spirit' star, a sort of participation trophy that shows it's taking pity on you. Stars come not only from building and

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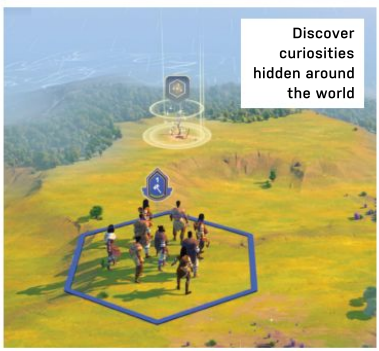
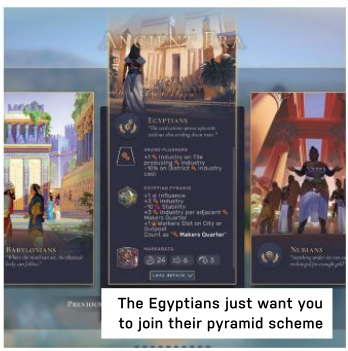




Hittites
Ancient Era
70
No, thank you. Take your feeble proposal elsewhere.
The Hittites have refused your Alliance Proposal
MU GUIYING
Bit rude! Avoid the Hittites, they don't seem very friendly

conquering but also from doing what your culture does, so a culture with an affinity for food growing will get one more quickly for farming than for engineering.

You need seven stars to advance to the next age, but you can hang around for a while if you're ahead of the competition to harvest more fame. You also get a fame bonus if you 'transcend'—keep the same culture for more than one age.

THE FAME GAME

There are other resources, such as money, influence, raw materials, but nothing drives the game forward quite like fame. Even if you manage to end the game by blasting off to Mars or reaching turn 300, you may not win if another culture has stockpiled enough fame. It can be tricky to completely wipe out an opposing culture—they always seem to pop up again somewhere—but, with their empire gone, they can't accrue fame, and that's the important thing.

Once you've got your head around this, the game plays quite differently from *Civ*. There is never a period when you even think about taking your foot off the gas, no point in consolidating your holdings for a few turns. Losing a city can be devastating to your fame, so battles become mobile skirmishes rather than grinding sieges, the diplomacy window a better place to settle grudges than the battlefield.

Likewise, the city stability number is never far from your mind, as an unhappy population can revolt. The more districts your city has, the larger its population cap and production abilities, but the lower its stability, so you need to build additional infrastructure to compensate. There's a lot to take in. It's a bit like *Civilization*.

Except this is an Amplitude Studios game, and you go in expecting it to be full of personality, like *Endless Space 2*, but what you get is a bit too close to the Firaxis template. The screen is covered with pop-up windows, and while you choose from a range of smirking avatars at the beginning of the game, you rarely get a sense of your culture's personality, even on the diplomacy screen, where the other cultures' representatives threaten and plead and chew the furniture.

It would be wrong to call *Humankind* bland. It's just not as spicy as we expected from the studio that produced Horatio and a society of sentient trees. It also closely resembles something we've all seen before, leaving the question of why not play *Civilization 6* instead. Do that, though, and you'll miss out on *Humankind*'s excellent new ideas. There's enough room in the world for more than one historical 4X, and Amplitude's decision to pile on the pressure means this one stands out for that alone. –IAN EVENDEN

VERDICT 8

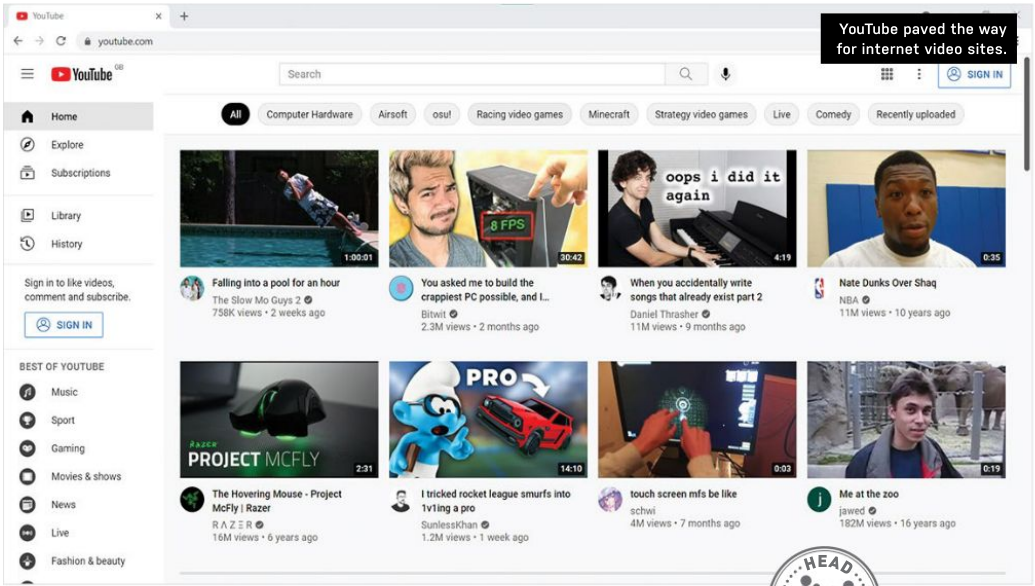
Humankind

FUN Vast historical 4X game; 300 turns of pressure and fame-management.

HUN Concept is perhaps a bit too similar to *Civilization*; could do with some more personality in the game.

RECOMMENDED SPECS CPU, i5 6600 / Ryzen 5 1600. RAM, 8GB. GPU, GTX 1060 / RX 5500 XT or better.

$50, https://humankind.game, E-rated



YouTube vs Twitch

Which of these video broadcasting giants is better?

VIDEO STREAMING can be split up into several different sectors: Most TV channels have an additional website for catch-up TV; there are subscription sites, such as Netflix, Amazon Prime, and Disney+, that charge a monthly fee to watch on-demand films and TV series: and then there are websites, such as YouTube and Twitch, that host unique content in the form of video clips or live streaming videos. These sites have helped the internet take over from traditional television as an entertainment medium. So, in this issue's head-to-head, we're going to focus on these two giants.

Now one of the main players in the online video industry, YouTube had humble beginnings. In 2005, Steve Chen, Chad Hurley, and Jawed Karim had the idea of a platform where people could share 'home videos'. These three ex-PayPal employees made this idea a reality and named it YouTube. Back then, the concept of an online space where people could find and watch unique content was revolutionary,

The first video on the site, called 'Me at the zoo', was uploaded by Jawed Karim on April 23rd, 2005 and was used to test the site. In May that year, the website launched as a beta and was soon racking up 30,000 visitors a day. By today's standards, that's tiny but back then, this was big news for a startup website. That figure soon rose exponentially, and by the time YouTube launched officially in December 2005, it was getting 2 million video views a day.

Some of YouTube's launch features are still fundamental parts of the website today. Video uploading and hosting, subscriptions, playlists, ratings, and full-screen mode were all available back then. Broadcasting content to the world gave everyone with a camera and a computer the chance to be a filmmaker and allowed people to become invested in the site.

By mid-2006, YouTube hit over 20 million monthly visitors, making it one of the fastest-growing sites on the internet. The technical demands of running a site this large meant more and more equipment and broadband connectivity were needed. On top of this, some of the content uploaded broke copyright laws. The owners looked to sell up and managed to hook a large buyer. On October 9th, 2006, Google bought YouTube for the tasty sum of $1.6 billion.

The purchase brought security to the site and saw some big changes, one of the biggest of which was the introduction of adverts. As annoying as they were (and still are), ads meant that creators could earn money from the site. Without this, YouTube and internet video consumption would be a completely different experience today. It's fair to say YouTube has changed not only the internet but also the wider entertainment and media industries too. Competitors such as Twitch probably wouldn't exist if it weren't for YouTube.

Though both are video streaming sites, they differ in terms of their content. Essentially, Twitch is YouTube but with live videos. Twitch began in 2007 when creator Justin Kan made a rig from a webcam strapped to a hat and a laptop in a backpack. He started live-streaming his life 24/7 on March 19th, 2007 and this live stream grew in popularity until, with the help of fellow computer programmers Emmett Shear, Michael Seibel, and Kyle Vogt, it became a channel, called Justin.tv.

This video site was purely for people to upload live content, essentially the internet version of TV. Gaming was a big driver of traffic from the start and though the site branched out into areas such as sports and music, copyright issues with illegally uploaded content meant that those areas had to be restricted. Gaming remained at the core of the site and eventually, in 2011, Justin.tv was relaunched as Twitch.

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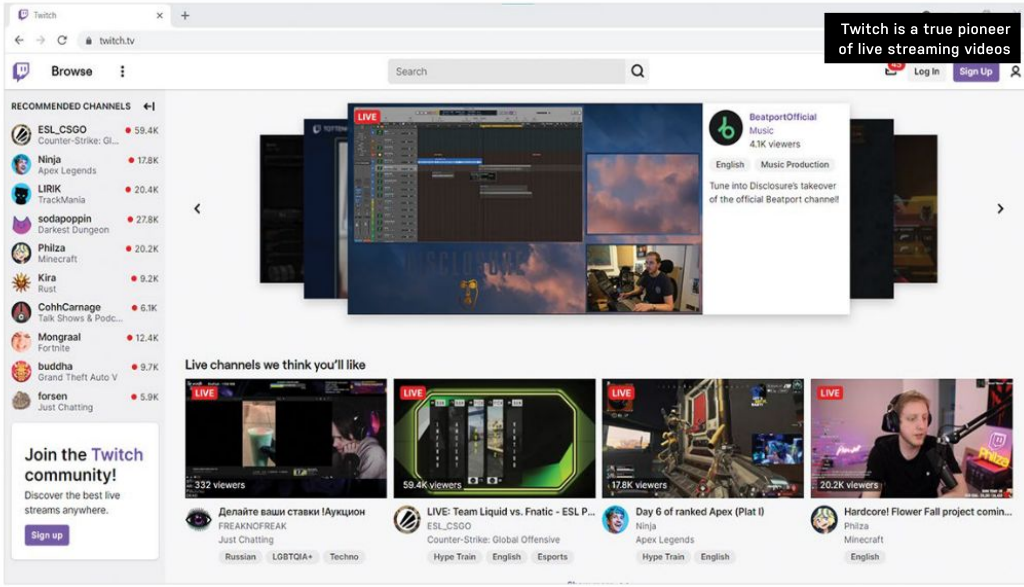

Over the years, both platforms have had countless updates and alterations but the formulas have remained the same. Though the two sites are similar, they are different enough to have co-existed for the past decade. YouTube is for content that has been planned out and created, which makes it a great place to let your creativity flow and to build an audience through editing and content.

Twitch is more of a place where the creators' characters shine and where they can express their personalities. While both sites offer similar content, watching something live on Twitch gives it a greater sense of anticipation than you get from a YouTube video. In 2017, YouTube attempted to muscle in on Twitch's USP by launching its own section for live streaming.

As far as design goes, YouTube certainly paved the way for the sites that followed. YouTube's site formula hasn't altered too much over the years and it remains easy to use. On the opening page, at the top, there is a search bar, the main part has suggested videos or channels you are subscribed to. On the left is a tab where you will find the home, explore, subscriptions, library, history, watch later, and liked videos sections. As a Google product, it is clean and easy to navigate around.

Unfortunately, the same cannot be said for Twitch. It's not exactly ugly, but it does look a little messy, particularly for the first-time user. On the left side of the website are your subscriptions and suggested followers. The main section of the site has a carousel with live streams, below that are your followed channels and categories. This is in view order and although it's a great way to see what is trending, it can get a bit crowded. Overall, YouTube is the better-designed site of the two.

But what about features? Since YouTube introduced a live streaming section, it has been a direct rival to Twitch. However, as a platform, YouTube doesn't prioritize streaming and its main focus is still non-live creator content. Twitch, on the other hand, is purely for live content and that remains its unique selling point.

YouTube is a more professional feeling platform with a much larger audience, but live streaming is better on Twitch. The communities built on the site are close to the creator and the interaction with your audience helps Twitch to be the best place to stream. Live streaming content on YouTube can feel lost and out of place.

The principles remain the same—if you want to watch videos, go to YouTube and if you want to watch live streams, go to Twitch. Even though YouTube has more features and is a more professional environment, YouTube's streaming section has yet to really challenge Twitch.

Overall, both sites have been a huge and vital part of the progression of the internet, with absolutely enormous catalogs of unique videos and billions of viewers, it's hard not to say that this new age of media consumption is gradually taking over.

YouTube takes the crown ahead of Twitch though. It is one of the biggest sites on the internet, it paved the way for video sites, and made a whole industry for creators to make money online. Although Twitch has followed a similar path and added live content to its platform, YouTube's extra features and better website design keep it ahead of its rival. –SAM LEWIS

VERDICT 9 — YouTube

THE GIANT Lots of great features; has changed video consumption; great for creators.

CRACKS IN THE WALL Has finger in too many pies; the live streaming aspect of the site isn't fully developed.

RECOMMENDED SPECS Newest version of Google Chrome, Firefox, MS Edge, Safari or Opera Internet connection with 500+ Kbps.

Free / $12 (per month) www.youtube.com

VERDICT 8 — Twitch

GREAT CONCEPT Revolutionized live streaming and the industry; highly interactive.

SMALL PROBLEMS Slightly overwhelming website design; focuses on live content.

RECOMMENDED SPECS Newest version of Google Chrome, Firefox, MS Edge, Safari or Opera Internet connection with 500+ Kbp.

Free / $5 (per month) www.twitch.tv.com

© TWITCH

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Lockdown IOT Devices
> Windows 10 Pricing
> Focus Assist

Network Security

Hey Zak, I recently bought some smart light bulbs and, reluctantly, I have had to connect them to my router on a guest network. I have a Pi-hole that acts as a DHCP server, so I ran into a few issues and ended up having to allow the guest network access to the Internet and LAN for it to work.

It made me think that it would be nice for you guys to do a write-up about the proper way to segment a home network to keep IoT devices from having access to the main network. And maybe you could even specifically include a Pi-hole as a DHCP server.

Thanks for your hard work on the mag. **–Shawn**

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: Hi Shawn, this is a pretty interesting idea actually, and I know just the man for the job! Ian Evenden is a bit of a Pi fanatic himself (he does most of our tutorials these days using the fruit-based computers), so I'm going to ask him to take a look at this over a few issues (we're in September as I write this, and the winter schedule is already fully booked up).

But I completely agree, it's something I personally take for granted. In fact, my network consists of about 33 devices in total, including various LIFX bulbs, Nest cameras and thermostats, Amazon Echos, Kasa smart switches, and suchlike (not forgetting the myriad "old-school" tech gadgets I have in the house), yet I've never really given it any thought.

You're right, these devices aren't exactly bulletproof, so giving them complete access to your main Wi-Fi network might not be the most intelligent of moves.

Blueprint OS pricing?

Why are your OS prices only $32 for Windows? Your build costs should reflect the consumer's price for Windows. **–M.Gates**

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: This is a question we get asked a lot, and understandably so. If you want a full-on Windows 10 license (which I genuinely recommend), it will set you back around $140. Now, every one of us here should at least have that as a bare minimum on their Microsoft account. It's well worth it, many times over.

For someone like me, who upgrades regularly, and changes machines on an almost monthly basis, all I have to do is log in to my Microsoft account on installation—whether that's Windows 10 or Windows 11—and the machine is activated and good to go.

Theoretically, you can build a complete system and not pay a cent. If you have Windows 10 already, you can create a bootable USB and leave the rig unactivated until a time where you can afford the license. Just remember not to connect to any Wi-Fi or Internet during the install process, and you can skip Microsoft sign-in and create a local account.

You occasionally get a watermark in the bottom right of the screen, and it locks out some of the desktop personalization options, for example, you are "technically" locked from changing the desktop background. However, if you right-click an image file, you can still "set image as background", and it will work just fine.

In fact, that's what we do on the majority of our test systems, as it's particularly useful for benchmarking.

However, as we're trying to keep the price down, and realize that's unreasonable with our blueprints, we actually use Kinguin (https://www.kinguin.net) to provide us with completely legal OEM keys for Windows 10. At the time of writing, they are listed at $32.53.

These are keys sold by Microsoft, in bulk usually, to third party system integrators, and other businesses, and suchlike. The keys those SIs don't use up, then get advertised on Kinguin at a lower price to recoup some cost for the businesses in question.

You can pick one of these keys up as an individual, then it's just a case of following a few simple instructions. There's a toll-free automated call you have to make once, but then you're done and activated.

It's worth bearing in mind however that these keys are a one-shot deal. If you change your motherboard, you will require a new key.

So, they're a solid choice, for an individual system, or something for a family member, but not something we'd recommend if you're a pro user or enthusiast who upgrades regularly.

↘ submit your questions to: editor@maximumpc.com

Reader Suggestions?

MaximumPC is currently the only magazine to which I am subscribed and I always look forward to each new issue and enjoy reading it. I like to keep updated on the latest tech developments and your magazine certainly plays a big part in that.

I know there are a lot of varied interests and priorities among your readers but, so far, I am pretty happy with the features I've read. Have you considered polling your reader base and getting some ideas for improvement or content suggestions?

–E. Lucas

EDITOR-IN-CHIEF, ZAK STOREY RESPONDS: This is something I've wanted to do for a long time, but finding a suitable avenue to do it is actually quite difficult—if only we had a website! At the moment, I'm toying with the idea of setting up an anonymous straw poll to allow people to vote in support of the PDF archives I'm so desperately trying to get our publishers, Future, to implement. But I totally agree, I'd love to send a full-on survey out with the magazine and get some real reader feedback.

For the time being, the best bet is to email me directly at either: editor@maximumpc.com or zak.storey@futurenet.com and I'll give them a read, and disseminate them where I can to the right people.

We've actually had a few really good recommendations recently for feature ideas, and even an entire list of ideas from one reader, which I promptly pushed on to Nick Peers, our in-house software genius, to cover. He's very grateful for those, and at least some of them will be making their way into the mag soon enough.

As you can imagine, it's quite difficult to get feedback, so any ideas or anything emailed our way helps a great deal. It's something I really do appreciate.

The Wrong GPUs?

Are your graphics cards mixed up in the end builds? Why do you have an AMD graphics card with an Intel processor and vice versa?

–R. Henshaw

EDITOR-IN-CHIEF, ZAK STOREY RESPONDS: Thankfully, we're a long way away from the days where one processor works best with one GPU and so on. What you're looking at isn't an error at all, and in our builds, a lot of the parts are interchangeable between the two systems.

So for instance, outside the Motherboard and CPU (and, to a degree, storage, depending on PCIe revision, and RAM as well, as we cater to higher speeds with AMD than with Intel), pretty much everything else is interchangeable between the two systems, including cooling, PSU, Graphics Cards, storage, and memory.

Do AMD graphics cards run faster on AMD processors? In our experience, only in certain scenarios, with certain games. You'll always find Intel or AMD have sponsored X title (the *Total War* series is a good example, they tend to flip flop back and forth between AMD and Intel), and in those cases, an AMD processor might give you the edge over Intel, and vice-versa, but it will be minor, maybe 10 percent higher average fps at most.

Otherwise, AMD and Nvidia cards work just as well across both platforms, especially now the two teams are so close to one another when it comes to single-core IPC performance. I'm currently running a version of the 4K gaming PC we did back in March with the Ryzen 9 5950X inside it, and I've swapped multiple times between Nvidia and AMD cards in the last few months without a single problem, or loss in performance.

Notification Trouble

Zak, I'm a long-time subscriber to *MaximumPC*. I keep about three years of back issues, after that the tech is mostly obsolete. You and the gang are doing a fantastic job covering the PC and accessories market and 'chasing technology'.

I really appreciate the detail you go into, as well as practical suggestions for building computer systems from scratch. Last year, I upgraded my office computer to an I5-9600K, new motherboard, memory, and video card, based on suggestions in *MPC*. Yes, now I have a TPM header on the MB. I'm looking forward to your future PC hardware articles and, of course, Windows 11 rollout.

Since you love challenges, perhaps you can help me and other readers with 'pest control'. More and more, I am getting pop-up reminders and ads in the lower right of my Windows 10 computer screen. These range from 'your programs need updating' and 'drivers need updating', to 'a new version of software is available', to name but a few. There has to be a way to kill those pests forever?

It may be a coincidence, but I don't recall Windows 7 doing this. There may be a Windows 10 'switch' somewhere I have missed.

Until now, I have been closing these pop-ups and basically tolerating them. Last week I was doing an online/Internet demonstration to a small group when an offer to buy an updated version of Corel Video Studio popped up. I use Video Studio for video editing. Canceling that, my Bitdefender popped up shortly thereafter reminding me that I was not using their VPN and I'm at risk. These companies need to mind their manners and stay off of my computer screen. I have Ad Blocker enabled on my Mozilla Firefox browser that I generally use. Any help you can provide will be most appreciated. **–I. Renga**

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: Yeah, this is a hangover from when Microsoft first announced Windows 10. When it changed its ecosystem from its traditional "pay for a license for each new version" to "Windows as a service with perpetual updates" type OS solution, the company had to come up with a new way to generate revenue.

One of those endeavors was through the use of advertising in both the start menu and the notification area of the toolbar (bottom right). That's why you'll see things like "Subscribe to Office 365" pop up there, and a myriad of other madness too. It's also where notifications pop up if you allow certain websites to send desktop notifications.

Some aspects of this are useful—getting driver update notifications is handy, especially if you're on my side of the gaming hobby. But I agree, in a professional environment like that, it's most uncalled for.

Fortunately, there is a simple workaround you can do with a feature called "Focus assist". Type that into your start menu, and it opens up a settings area. Here you can change what notifications appear and when, set up priority lists for certain notifications to come through, stop all notifications coming in at certain times, and so on.

It's similar to the "Do not disturb" feature found on most phones these days and would certainly be extremely useful during those presentations.

It's here for the time being as it still features in Windows 11, and hopefully will do going forward too.

THE BUILDS

THIS MONTH'S STREET PRICES...

AFTER SOME DICEY CPU STOCK SITUATIONS last month, we're pleased to report that our budget builds have returned to a (somewhat) more normal state. The Ryzen 3 3100 we promised last time is here, available for a reasonable $200. The 3100 brings us a tidy 8-thread processing solution, offering significantly boosted performance over the Ryzen 3 1200 we had to settle for last month. That third-gen Ryzen chip means we have access to PCIe 4.0 once again, so we splashed out and upgraded our mobo for a further 20 bucks.

This MSI B550M Pro motherboard guarantees speedy transfers in the budget AMD machine; so naturally, we need a new M.2 SSD to run those speedy transfers. We opted for XPG's Gammix S50 Lite PCIe 4.0 drive—not the fastest Gen4 M.2 SSD, but with half a terabyte of storage for 70 bucks, it's one of the best-value options.

Unfortunately, Intel motherboards seem to be having difficulties right now. The B460M boards we've recommended are either jacked up in price or unavailable (stock for the Gigabyte DS3H V2 we featured ine the last issue is non-existent), so we've had to settle for the more expensive—albeit more visually appealing—B460M Steel Legend from ASRock. The price of the Core i3-10100 has also climbed a little, but not so much as to provoke a CPU swap.

The 1TB Western Digital hard drives in both of these budget machines dropped $5 this month, making them the most reliable and affordable bulk storage around. The Intel budget machine might not have PCIe 4.0, but still gets an SSD capacity bump courtesy of a sale on Team Group's Cardea Zero Z330 M.2 drive, a steal at $54.

Have our GPU prices dropped yet? Sadly, no... we'll be waiting some time for those graphics cards to return from the crypto wars. With scalpers abounding across the internet, stocks in the U.S. are dire; camping out online restocks at Best Buy, Newegg, and Walmart are the best options, unless you're willing to drop 200 percent of RRP on a 'lightly used' card from eBay (tip: don't do this).

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	500W EVGA BA 80+ Bronze	$50	
Mobo	MSI B550M PRO AM4 NEW	$90	
CPU	AMD Ryzen 3 3100 NEW	$200	
GPU	AMD Radeon RX 6700 XT 12GB NO STOCK	$480	$840
RAM	16GB (2x8GB) Crucial Ballistix @ 3200MHz	$75	
SSD	512GB XPG GAMMIX S50 Lite PCIe 4.0 M.2 SSD NEW	$70	
HDD	1TB WD Blue 1TB 7200	$40	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,132 or $1,492**	

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	500W ARESGAME AVG500 80+ Bronze	$45	
Mobo	ASRock B460M Steel Legend NEW	$108	
CPU	Intel Core i3-10100	$167	
GPU	Nvidia GeForce RTX 3060 12GB NO STOCK	$330	$700
RAM	16GB (2x8GB) Crucial Ballistix @ 3200MHz NEW	$75	
SSD	512GB Team Group T-Force Cardea Zero Z330 PCIe 3.0 M.2 NEW	$54	
HDD	1TB WD Blue 1TB 7200	$40	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$946 or $1,316**	

QUICK, THE RYZEN 5 5600X IS ON SALE AGAIN! And, by the time you read this, it'll be back to RRP. Or on sale again. Our point is that if you're after a solid midrange CPU, keep an eye on this chip's price because snapping one up for under $280 is a great idea. The Core i7-11700K in our midrange Intel machine isn't quite as affordable, but unlike budget CPUs, these prices seem to be holding steady for now. Our two motherboards here remain the best-value pickings, so there wasn't much to tweak in the midrange builds.

Fractal Design's excellent Ion Gold PSUs are still great value so the AMD system hangs onto its power brick, but we've swapped out the power supply in the Intel build for a Corsair TX650M model this month. Similarly, our pair of 240mm AIO coolers dropped in price by $10 apiece, so no need to change them out this time around either.

Both systems will, however, benefit from new RAM this month. Memory prices might be in constant flux, but we're taking those minor savings and bumping both midrange machines up to some carefully selected CL16 RAM. In the AMD build, that's the ever-reliable Crucial Ballistix memory (in sleek matte white), while the Intel build gets treated to Kingston's new FURY Renegade RGB kit. We say 'new'; Kingston and HyperX recently parted ways in RAM production, resulting in a swift rebrand of the FURY memory line. These new RGB DIMMs do look nice, though, with a black finish and a subtle lightstrip across the top.

Corsair's 500GB Force MP600 PCIe 4.0 drive has dipped down to a charming $90, joined by similar offerings from Gigabyte and Sabrent. The PNY CS3040 SSD seen last month in the AMD midrange build held firm at $100, though, so we're shaving off another 10 bucks by jumping ship to Sabrent's Rocket drive. As we mentioned in the budget build notes, the 1TB WD Blue drives are starting to look like a permanent fixture in these builds; sadly, our 'NO STOCK' GPU warnings are looking the same way.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$150	
PSU	650W Fractal Design Ion Gold	$90	
Mobo	Asus AM4 TUF Gaming X570 -Plus WiFi	$195	
CPU	AMD Ryzen 5 5600X	$273	
Cooler	240mm Cooler Master Masterliquid ML240L RGB	$60	
GPU	Nvidia GeForce RTX 3070 8GB **NO STOCK**	$500	$1,150
RAM	16GB (2 x 8GB) Crucial Ballistix @ 3600MHz **NEW**	$91	
SSD	500GB Sabrent Rocket M.2 PCIe 4.0 SSD **NEW**	$90	
HDD	1TB WD Blue 1TB 7200	$40	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,521 or $2,171**	

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$150	
PSU	650W Corsair TX650M 80+ Gold **NEW**	$95	
Mobo	ASRock Z590M PRO4	$150	
CPU	Intel Core i7-11700K	$400	
Cooler	Enermax Liqmax III 240 RGB	$60	
GPU	AMD Radeon RX 6800 XT 16GB **NO STOCK**	$650	$1,450
RAM	16GB (2 x 8GB) Kingston FURY Renegade RGB @ 3600MHz **NEW**	$95	
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0	$90	
HDD	1TB WD Blue 1TB 7200	$40	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,762 or $2,562**	

WE SPIED A SALE on Western Digital's 3TB 5400RPM HDDs, and at 60 bucks a drive, doubling up on these proved cheaper than a single 6TB HDD at the same RPM. Yes, 7200RPM HDDs are faster, but these chunky drives are for secondary storage, and both our turbo builds have a terabyte of super-speedy PCIe 4.0 SSD space anyway.

Speaking of which, the Samsung 980 Pro is no longer on sale, so Sabrent steals the SSD slot of our turbo AMD machine with its Rocket 4 Plus SSD, which offers speeds just below Samsung's finest. The similarly fast 7000s from Gigabyte keeps its place in the Intel system, for now. 1TB PCIe 4.0 SSDs offer a wide price range, but more expensive models don't necessarily offer higher speeds; check the reviews rather than take the manufacturers at their word.

Both our builds get new 4000MHz memory, as the previous G.Skill Ripjaws V RAM is no longer available at a discounted price. We kept things sleek and simple in the Intel machine with the T-Force Dark Za kit, while the AMD system stuck with G.Skill but gained some shiny new RGB lighting from the 2x16GB Trident Z Neo kit.

There was nothing else for us to reasonably tweak in our AMD turbo PC this issue; Corsair's awesome 360mm Capellix cooler remains one of the best AIOs for powerful systems, and pricing on our other components here remained largely unchanged.

Our Intel machine has had some new additions. Fractal Design's Ion Gold PSUs aren't just good for mid-range builds; the 750W and 850W models are budget-friendly power supplies, considering their general build quality and a seven-year warranty. For $100, the 750W version is a shoo-in for a beefy build like this.

The Intel turbo build also gets a new motherboard, matching its MSI MAG cooler with a MAG mobo. That's the MSI MAG Z590 Tomahawk WiFi at $230 (down from $270). This has all the bells and whistles you need, from PCIe 4.0 support to built-in 802.11a/b/g/n/ac/ax wireless and memory overclocking headroom to support that speedy RAM we're using. If you use a wired internet connection, you can shave $30 off by opting for the WiFi-free MAG Z590 Torpedo.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$150	
PSU	750W NZXT C750 80+ Gold	$110	
Mobo	MSI MPG X570 Gaming Edge Wi-Fi	$200	
CPU	AMD Ryzen 7 5800X	$400	
Cooler	Corsair iCUE H150i ELITE CAPELLIX AIO 360mm	$168	
GPU	Nvidia GeForce RTX 3080 10GB **NO STOCK**	$700	$1,650
RAM	32GB (2 x 16GB) G.Skill Trident Z Neo @ 4000MHz **NEW**	$180	
SSD	1TB Sabrent Rocket 4 PLUS M.2 PCIe 4.0 **NEW**	$180	
HDD	2x 3TB WD Blue 5400 HDD **NEW**	$120	
OS	Windows 10 Home 64-bit OEM	$32	

Approximate Price: $2,240 or $3,190

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$150	
PSU	750W Fractal Design Ion Gold **NEW**	$100	
Mobo	MSI MAG Z590 Tomahawk WiFi **NEW**	$220	
CPU	Intel Core i9-11900K	$545	
Cooler	MSI MAG CoreLiquid 360R AIO	$121	
GPU	AMD Radeon RX 6900 XT 16GB **NO STOCK**	$999	$1,600
RAM	32GB (2 x 16GB) Team Group T-Force Dark Za @ 4000MHz **NEW**	$175	
SSD	1TB Gigabyte Aorus Gen4 7000s M.2 PCIe 4.0	$190	
HDD	2x 3TB WD Blue 5400 HDD **NEW**	$120	
OS	Windows 10 Home 64-bit OEM	$32	

Approximate Price: $2,652 or $3,253

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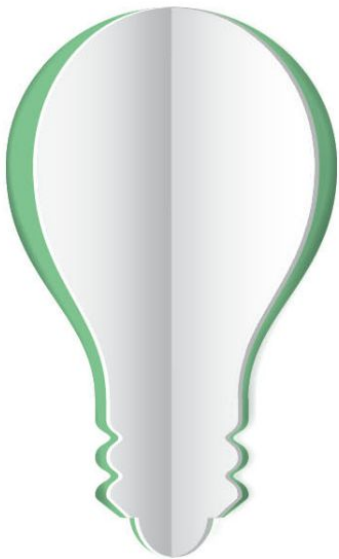

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